

DISPOSAL OF WASTE PESTICIDES AND PESTICIDE  
CONTAINERS BY TASMANIAN FARMERS

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ABSTRACT

The subject is introduced with short reviews of the effects of pesticides in the environment, and of the fate of pesticides in the environment. A general review of the subject matter considers the magnitude and nature of the problem, methods of pesticide disposal appropriate in Tasmania, costs and legal aspects of disposal, and the effectiveness and effects of pesticide and container disposal. A detailed account of Tasmanian farmers' knowledge and practice of container and pesticide disposal is given, as well as some insight into farmer attitudes, and the magnitude of the problem in Tasmania. Implications of the study are discussed, and suggestions made for future research and action.

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## CHAPTER 1

### INTRODUCTION

Pesticides<sup>1</sup> are chemicals which are designed to kill or inhibit the growth or development of a wide variety of life forms which adversely affect Man's attempts to produce food and fibre of plant and animal origin. They have the capacity also to affect adversely a wide range of organisms not intended as targets, including humans, domestic livestock, wildlife and many other species. The actual contact between pesticides and non-target species which may lead to adverse effects, is the result of a number of factors, and one of the most important of these is the property of a pesticide to move away from the point of its release into the environment<sup>2</sup> where it may continue to exert biological effects. It has been demonstrated that the agencies of wind and water can disperse certain pesticides over thousands of miles<sup>3</sup>, so both the geographical distribution of non-target species, and the range of the species which may have unintended contact with pesticides, are potentially very broad. However, whilst the process of pesticide application is relatively indiscriminate and leads often to wide dispersal of pesticides, some aspects of pesticide use and handling more in the nature of ancillary activities, do allow the chance not only of putting pesticides exactly where wanted, but also of expecting them largely to remain where placed. Among these activities are the practices of disposal and storage of pesticides and their containers.

Between the time of bringing a pesticide onto his property, and being completely finished with it, the farmer<sup>4</sup> will handle a pesticide and its container a number of times in a variety of ways. Because of the hazardous nature of many pesticides, certain precautions and safety measures should be taken by the farmer throughout the lifetime of a pesticide on the farm. Among these measures are the precautions of correct storage, and correct disposal of waste pesticide and pesticide containers. Little research on these three facets of pesticide handling by the farmer has been carried out in Australia, and in general, interest among appropriate Australian organizations in any aspects of disposal and

storage has been relatively small. The response to exploratory letters to a wide variety of institutions is summarized in Appendix I.

Durable guidelines for storage and disposal procedures suitable for the farmer, have been established, but with the exception of one survey carried out in New South Wales, there appears to have been no assessment of actual farmer practices in Australia. Research into new or existing disposal techniques, or investigation of the development of infrastructures to facilitate disposal at farmer level are both largely neglected areas in Australia. Furthermore, legislation in Australia on disposal by farmers is usually covered only under general State environmental legislation, rather than specific pesticide legislation.

These points raise three important questions. Firstly, what, if anything, is known in Australia or Tasmania of the potential dangers and actual damage arising from current disposal and storage practices of farmers? Secondly, what understanding is there of the many factors which lead farmers to adopt certain disposal and storage practices? And thirdly, why have research and legislation in particular, and to a lesser degree, education around these issues, received very little attention in Australia? The reasons may stem from the topic's intrinsic lack of interest, from the belief that low priority attention is necessary or appropriate, from the conviction that the combined contributions of overseas and local authorities are adequate, or simply, from the belief that no problem exists.

At the time when this project was first considered, not only were activities around, and information on pesticide disposal and storage in Australia and Tasmania scarce, but also there was little to suggest that this situation would change in the near future<sup>5</sup>. Given such circumstances, the most practical approach to a study of farmers' disposal and storage practices would be one which was broad, and which, within reason embraced as many disposal- and storage-related issues as practicable. The principal aim should be the examination of farmer practices in such a way that assessment of the actual and potential hazards which result, may be made. With a view to understanding and perhaps changing such habits, a number of questions must be asked: for example, does the farmer have the appropriate knowledge to store or dispose of pesticides correctly? Have there ever

been chances to obtain this knowledge? Could the farmer's attitudes towards pesticides in general, or towards disposal and storage specifically, influence his practices? What are the farmer's perceptions of the disposal problem, and how good is his general knowledge of pesticides? Does he have any worthwhile views on how the tasks of disposal and storage could best be executed for or by him? Do legal factors influence his behaviour? The survey of farmers undertaken as part of this project asked all of these questions and others so as to make possible a full assessment of farmers' actual practices.

Chapters 2 and 3 present the reader with background information to the survey. In Chapter 2 is an outline of the undesired effects caused by pesticides released in the environment. Also, factors in the environment which may change the activity of pesticides are considered. In Chapter 3, many of the principles introduced in Chapter 2 are applied to actual disposal and storage. There is a consideration of the magnitude and nature of the disposal problem, a look at correct methods of disposal and storage, and the effects and costs involved, as well as a review of legal aspects. All aspects of the farmer survey are described in some detail in the Annexe, and findings of the survey and other research are summarized in Chapter 4. In the same chapter, implications of the various findings are discussed and integrated. Finally, Chapter 5 presents conclusions and recommendations coming from the whole project.

It needs to be mentioned here that the farmer is not the only person faced with a need to store pesticides, or dispose of pesticide wastes: the manufacturer, the distributor (retailer), the pesticide spray contractor (including aerial sprayers) and other users of pesticides such as government institutions are also faced with the need. Generally, these needs would be greater than the farmers'. However, this treatise concentrates almost entirely on the farmers' practices for four reasons. Firstly, Tasmania has no pesticide formulating or manufacturing<sup>6</sup> industry, which are probably the greatest generators of pesticide waste. Secondly, because of his broad geographical distribution through the State, the farmer has the potential to expose non-target species to pesticides over a greater area than any other party in the State generating wastes. Thirdly, a survey approach to the problem would make possible the investigation at farmer level not

only of aspects of storage and disposal, but also of other related and generally pertinent issues. Finally, as mentioned, surveys of this type at farmer level have not previously been carried out in Tasmania, or in such detail, anywhere in Australia.

#### Agriculture and pesticide use in Tasmania

The geographical distribution of both population and agriculture in Tasmania differs somewhat from that of mainland Australia<sup>7</sup>. In Tasmania the population is relatively evenly dispersed, and although 84% of the population lives within 40 km of Hobart, Launceston and Ulverstone, much agricultural activity is found in these areas. With the exception of the south-west and the west coast area, agriculture of one type or another is practised almost right across the State. The main agricultural produce is vegetables, hops, poppies, cereals (mainly wheat, barley and oats), and fruit (mainly apples). Animal produce includes dairy products, beef, pork, prime lamb, mutton and wool. It is of some relevance to the theme of this document that agricultural soils are generally podsoles, i.e., grey coloured soils of light texture usually with a clay subsoil. The main exceptions to this are the deep red loams and chocolate volcanic soils of the north-west and north-east, and the alluvial soils of the mid-Derwent valley<sup>8</sup>. Throughout the State, the rainfall tends to be evenly spread through the year, although much of the summer rain falls in short periods<sup>9</sup>.

Since the beginnings of organized agriculture some 10,000 years ago, Man has constantly sought techniques which would reduce the need for physical human input. The existence of agricultural pests<sup>10</sup> and their effects have been known for thousands of years, but control methods which are both effective and labour non-intensive by earlier standards, and which have broad agricultural application, have only been available since the Second World War. Together with many other advanced agricultural techniques, modern pest control using chemicals has increased greatly in the last 30 years, particularly in developed countries like Australia.

The use of pesticides in Australia has been, and will most likely continue for some time to be an accepted and integral part of many types of agricultural and animal production, of home gardening, and in some municipal and industrial situations where pests occur. Australia is heavily dependent



on agriculture for its well-being. It is also the user of significant quantities of pesticides, and use increased by approximately 5% last year in real terms - considerably less than in previous years. The quantity being used is not the only change in train: a gradual change in the type of pesticide being used is occurring such that the new products coming onto the market are of lower acute toxicity<sup>11</sup> and lower persistence<sup>12</sup>. These changes are of great environmental significance (see Chapter 2).

The value of world-wide sales in 1980 of crop-protection chemicals was estimated to be approximately A\$10.1 billion<sup>13</sup>. In Australia, it is approximately A\$180 million, and in Tasmania an estimated A\$6 million. Unfortunately, it is impossible to obtain any estimate of the weight of pesticide active ingredient being sold annually.

## NOTES

1. A pesticide, for the purposes of this document, is "any substance or mixture of substances intended for preventing or destroying, repelling or reducing the harmful effects of any insects, rodents, nematodes, fungi, weeds, and other forms of plant or animal life or viruses, except viruses on or in living man, or other animals, and, any substance or mixture of substances intended for use as a plant regulator, defoliant or desiccant". See, PESTICIDES SECTION, Department of Primary Industry, 1980; A manual of safe practice in the handling and use of pesticides, Australian Government Publishing Service, p.3. This definition is intended to include preparations for the treatment of external parasites of animals, but not those for the treatment of internal parasites, or for any other veterinary purpose.
2. EDWARDS, C. A., 1973; Persistent pesticides in the environment; C.R.C. Press, Inc; Ohio, U.S.A.
3. As above, p.24.
4. 'Farmer' is used to describe that person who, as part of private enterprise produces cereals, wool, beef, dairy products, prime lamb, cereals, fruit, vegetables, hops, etc. ie it refers to the whole range of activities commonly associated with farming.
5. At the time of writing this report, there was no indication of increased interest in disposal of pesticides or containers on the farm. However, considerable activity in relation to hazardous industrial wastes was manifested in the form of four major reports:
  - a. HOUSE OF REPRESENTATIVES STANDING COMMITTEE ON ENVIRONMENT AND CONSERVATION, 1982; Hazardous chemical wastes: storage, transport and disposal, first report on the inquiry into hazardous chemicals; Australian Government Publishing Service, Canberra, Australia.
  - b. AUSTRALIAN ENVIRONMENTAL COUNCIL and CONFEDERATION OF AUSTRALIAN INDUSTRY, 1981; Management and disposal of hazardous industrial wastes; Maunsell and Partners, Pty. Ltd., Canberra, Australia.

5.     c.    ANON., 1981; Disposal of intractable wastes in Victoria - a draft strategy. Environment Protection Authority, Melbourne, Australia.
- d.    ANON., 1981; Incineration facilities for industrial liquid waste disposal - a feasibility study; Environment Protection Authority, Melbourne, Australia.
6.    'Manufacturing' normally refers to the synthesis of the active ingredients of pesticides, and is mostly a process carried out by parent companies (as opposed to subsidiaries, which describes most Australian purveyors of pesticides). 'Formulation', which *is* commonly carried out in Australia but not Tasmania, refers to the preparation of a product from the active ingredient which the farmer can use. This involves the addition of wetting agents, emulsifying agents, etc.
7.    ANON., June 1980; Agriculture in Tasmania. (pamphlet); Department of Agriculture, Tasmania.
8.    As above.
9.    As above.
10.   As Note 1, wherein are mentioned agents causing harmful effects.
11.   The acute toxicity of a substance is a quantity-related expression of that substance's ability to cause immediate damage to an organism.
12.   Persistence of a pesticide refers to its ability to remain chemically unchanged and biologically active in the environment. DDT is a highly persistent chemical, pyrethrins are generally not.
13.   ANON., 1981; A look at world pesticide markets, Farm Chemicals 144, (9), 55.

## CHAPTER 2

### PESTICIDES IN THE ENVIRONMENT - FATE AND EFFECTS

The preceding chapter mentioned briefly some of the properties of pesticides which underlie their behaviour and effects in the natural environment. Pesticides released into the environment are part of a two way process: they bring about a variety of biological effects on a wide range of organisms, and conversely, both biotic and abiotic factors combine to act on, and often change the pesticides. This chapter introduces the reader to these various phenomena in greater detail, emphasising particularly aspects relevant to pesticide disposal.

As a prelude to the discussion, the reader is introduced to some of the more common chemical groups into which pesticides are often classified. Pesticides can be classified according to targets, chemical groups, and many other categories. The classification below is based on targets and chemical groups:

- a. *Insecticides and miticides* include the chemical groups organophosphorus compounds, organochlorine compounds, pyrethroids, carbamates, and inorganic compounds.
- b. *Herbicides* (weedicides) include the groups phenoxyacetics, dinitrophenols, substituted ureas, triazines, and bipyridyls.
- c. *Fungicides* include thiocarbamates and dithiocarbamates, thioureas, carboxanilides, and mercurials.

Beyond these three major target groups are further groups such as rodenticides, avicides, nematocides, molluscicides, algicides, plant growth regulators and others. The chemical formula of each pesticide mentioned in the text of this document, and also the target group to which each belongs is given in Appendix II. It should be noted that some of these chemical groups, such as organophosphorus compounds and carbamates, may be used against more than one target group.

The first part of this chapter outlines briefly the effects of pesticides released into the general natural environment. The second part considers the fate of pesticides in the environment.

## 2.1 EFFECTS OF PESTICIDES IN THE LIVING ENVIRONMENT

Because the action of the vast majority of commonly used pesticides is rarely, if ever, specific to one target species, it is likely that many other (non-target) species, if contacted by a pesticide, will be affected in some way. Among the non-target species sometimes exposed to pesticides is man, and in fact, organisms at all taxonomic levels can be affected<sup>1</sup>. A number of factors influences the severity of the effects including the duration of exposure to the pesticide, the quantity, toxicity and concentration of the chemical, and the route of absorption into the organism. Ideal pesticide and container management and disposal aims at minimising, or reducing to nil, all potential risks posed by these wastes before and after disposal.

Widespread concern about the effects on man and the environment caused by dispersal of pesticides was first aroused in the early sixties by the publication of Rachel Carson's Silent Spring<sup>2</sup>. By bringing to the world's attention the existence of undesirable effects attributable to pesticides, an important advance was made. However, in using emotional and factually flawed argument<sup>3</sup>, she committed a disservice and set an example which has remained as fashionable and misleading as it was then<sup>4</sup>. The scientific literature describing the effects of pesticides on the natural environment embraces retrospective<sup>5</sup> and predictive<sup>6</sup> studies, laboratory<sup>7</sup> and field<sup>8</sup> work, and empirical<sup>9</sup> and theoretical<sup>10</sup> approaches. Few studies have attempted to put a monetary value on the undesired effects caused by pesticides, but recently Pimental et al<sup>11</sup> published a preliminary assessment of the environmental and social costs which accrue to their use. Taking into account such factors as poisoning of humans, domestic livestock and bees (with subsequent effects on pollination), and losses of fish and wildlife among others, they concluded that annual costs in the United States, excluding the actual cost of pesticide, is approximately U.S.\$840 million. A simplistic extrapolation to the Australian situation, based purely on the relative value of pesticides used in each country, suggests costs in Australia of about A\$43 million annually.

In an earlier review, Pimental<sup>12</sup> categorised the effects of pesticides in the environment into nine types of action: (i) reduction of numbers within

a species; (ii) habitat change (particularly vegetation) and subsequent reduction of the number of species; (iii) behavioural change; (iv) growth changes; (v) altered reproduction; (vi) change of food quantity and quality; (vii) pesticide resistance; (viii) increased disease susceptibility; and finally, (ix) biological concentration of pesticides along food chains. All of these effects give rise to deaths either as a primary result of exposure to pesticide, or as a result of reduced vigour of an organism or population which leads to deaths from indirect action of pesticides. Further detail can be obtained from the original papers cited, and also from Rudd<sup>13</sup>, Perring and Mellanby<sup>14</sup>, Cope<sup>15</sup>, Gunn and Stevens<sup>16</sup>, Kenaga<sup>17</sup> and Brown<sup>18</sup>.

Australian work on the effects of pesticides on non-target species is relatively scarce: a meeting convened in 1980 by the Co-ordinating Committee on Agricultural Chemicals<sup>19</sup> found that

*... there are relatively few objective data on the effects - particularly long-term - of pesticides on Australian native fauna species and especially on wildlife populations. The reasons for this include the fact that the existence of a major problem has not been established; the technical complexities involved in measuring changes in wildlife populations; and the fact that qualified staff for field work and for laboratory analysis of pesticide residues<sup>20</sup> are not available.*

However, it was also noted that

*Fish and Wildlife Authorities are greatly concerned that the adverse effects of normal use of agricultural chemicals could be much greater than is generally believed<sup>21</sup>.*

This concern arises from lack of toxicity data for Australian native fauna, from several studies which have found significant residues of organochlorine in native fauna, and from the fact that native fauna may have a generally higher sensitivity to pesticides than the northern hemisphere species commonly used for toxicity tests. A recent Tasmanian survey<sup>22</sup> of residues of DDT and metabolites, lindane, dieldrin and hexachlorobenzene in fish, birds and mammals found residues of 0.1 ppm<sup>23</sup> in at least one individual animal from the 57 locations sampled. For most locations, this was true

of the majority of animals sampled. However, this assessment of the Tasmanian situation is disappointing because a number of the species sampled were migratory in habit, and therefore residues do not necessarily reflect Tasmanian conditions<sup>24</sup>. Other Tasmanian studies on the peregrine falcon (Falco peregrinus) and their eggs have shown body residues of DDT and egg shell thinning<sup>25</sup>. Studies of the effects of Compound 1080 (sodium mono-fluoroacetate) on Tasmanian wildlife have also been carried out, and whilst it was found that non-target species were affected, target species were far more seriously affected<sup>26</sup>.

Recommendations which came from the Co-ordinating Committee on Agricultural Chemicals, included, among other things, a suggestion for development of predictive techniques for assessment of effects of pesticides on Australian native fauna. Whilst such research would be of value, its cost in time and money as well as the problems associated with establishing a scientific basis for prediction preclude any likelihood of such work. However, guidelines for assessment of the relevant environmental parameters of pesticides by registration authorities have been put forward by the Food and Agriculture Organisation<sup>27</sup>, GIFAP<sup>28</sup>, the Council of Europe<sup>29</sup> and the British Ministry of Agriculture, Fisheries and Food<sup>30</sup>, and these criteria have been adopted by local registration authorities.

Two further aspects of the effects of pesticides in the environment require specific comment: the effects on man, and the effects on flora and fauna of the soil. Effects on humans are of concern in all uses and for all fates of pesticides; effects in the soil are very important in the context of pesticide disposal.

Exposure of humans to pesticides occurs in a variety of ways: directly in the course of application, as drift from application in an adjacent area, from water which has been contaminated, from food containing residues, from exposure during the manufacturing process, and so on. Absorption into the body may be from the lungs (following inhalation of air-borne pesticide), through the skin, or from the digestive tract (following ingestion). The route of absorption is very important in determining subsequent effects of a pesticide.

Recognizable symptoms of poisoning arising from contact between pesticides and humans are usually described as acute or chronic<sup>31</sup>. Acute effects are prompt in onset, of short duration and may be non-specific, systemic or localized. For certain classes of pesticide, the effects are consistent and well characterized for the whole group, but this is not generally the case. At worst, acute effects result in death because of gross disturbance of biochemical or other functions. Chronic effects of pesticides are a result of low-grade continual exposure and effects are generally slow in onset, protracted or recurrent, and maybe irreversible. Chronic effects include such things as peripheral neuropathies, reproduction dysfunction, sensitization, and suspected but often unconfirmed effects like organic damage to the brain, heart, lungs and other organs, carcinogenesis, teratogenesis<sup>32</sup>, mutagenesis<sup>33</sup>, arteriosclerosis and others.

From a functional point of view, these effects lead to mortality or increased morbidity<sup>34</sup>, and clearly, exposure to pesticides should be kept as low as possible. This may be achieved, for example, by the use of protective clothing when spraying with pesticides, but total avoidance of pesticides in food, the source of 90% of intake<sup>35</sup>, is more difficult because it is a low-grade and largely ubiquitous source of exposure. Records of poisoning by pesticide in Australia are given in some detail in Appendix III, but little information is available on the situation in which the poisoning occurred<sup>36</sup>. Assessment of the role of inadequate storage or disposal as causes of poisoning is therefore difficult.

The effects of pesticides on soil-dwelling organisms are of potential significance for two reasons. Firstly, organisms in the soil are responsible for the functioning of some major natural cycles, namely, the carbon, nitrogen, sulphur and phosphorus cycles, among others. Interference in the functioning of these cycles has far greater implications for the natural environment than the effects on more visible and aesthetically appealing species. Secondly, as described in Chapter 3, a number of techniques of pesticide disposal involve soil micro-organisms directly.

In a brief review such as this, the many and varied effects of pesticides in the soil cannot be adequately covered. Reviews by Parr<sup>37</sup>, Simon-Sylvestra et al<sup>38</sup>, Brown<sup>39</sup>, and Edwards et al<sup>40</sup> make amply clear the reason for this.



Simply, the great number of pesticides and even greater number of soil-dwelling species make generalization difficult. Anderson<sup>41</sup> makes some attempt at a generalization by using an 'effect ratio'. Derivation of this figure is poorly explained, but it has its origins in the many scientific studies of the interactions of pesticide and soil micro-organism. Appendix IV presents some of these generalizations, and describes the effects of the target groups herbicides, fungicides, insecticides and others on such things as bacterial numbers, nitrification<sup>42</sup>, nitrogen fixation<sup>43</sup>, soil pathogens, etc. The reviews mentioned above give the reader more detailed information on these aspects of pesticide behaviour. It must be pointed out, however, that whilst such basic phenomena as the carbon and nitrogen cycles may be influenced by the actions of pesticides in the soil, such effects are generally transient and of no widespread concern<sup>44</sup>.

## 2.2 FATE OF PESTICIDES IN THE ENVIRONMENT

Whilst the general principles which apply to the fate of pesticides released into the environment are fully introduced under this heading, the general treatment of this subject emphasises aspects of specific importance to this document. Of great importance during the life of a pesticide molecule in the environment are the movements of this molecule in the environment, its ability to resist molecular change, and the changes undergone which alter its toxicity. The fundamental aim of pesticide disposal is to render the pesticide harmless to all living organisms; the influences in the environment which accelerate or hinder this process are discussed in this exposé.

A variety of factors may alter the status of each pesticide molecule released into the general environment, and these may be classified into processes which chemically alter the molecule, and those which do not. Those processes not chemically modifying the molecule often influence mobility or immobility of the compound. Processes changing the molecule have a great bearing on its toxicity, and persistence. When considering effective disposal, the processes of chemical change and of movement are very important, the general aim being minimization of movement and maximisation of chemical change. Ultimately, however, chemical change is a more likely determinant of the success of disposal.



situation mass flow in water, and possibly in air, could be very important. Movement of a pesticide into water is influenced by its solubility in water, the availability of water, concentration or amount of pesticide in the deposit, and local factors such as topography, vegetation, soil type, etc.<sup>54</sup>. The relative mobility of different pesticides in soils has been summarized by Helling et al<sup>55</sup> as in the table below. In general, organophosphorus compounds are more mobile than organochlorines which are the least mobile of all. Herbicides are generally more mobile than fungicides, insecticides, or acaricides.

Mobility Class				
5	4	3	2	1
TCA	Picloram	Propachlor	Siduron	Neburon
Dalapon	Fenac	Fenuron	Bensulide	Chloroxuron
2,3,6-TBA	Pyrichlor	Prometone	Prometryne	DCPA
Tricamba	MCPA	Naptalam	Terbutryn	<i>Lindane</i>
Dicamba	Amitrole	2,4,5-T	Propanil	<i>Phorate</i>
Chloramben	2,4-D	Terbacil	Diuron	<i>Parathion</i>
	Dinoseb	Propham	Linuron	<i>Disulfoton</i>
	Bromacil	Fluometuron	Pyrazon	<i>Diquat</i>
		Norea	Molinate	<i>Chlorphenamidine</i>
		Diphenamid	EPTC	<i>Dichlormate</i>
		<i>Thionazin</i>	Chlorthiamid	<i>Ethion</i>
		Endothall	Dichlobenil	<i>Zineb</i>
		Monuron	Vernolate	<i>Nitralin</i>
		Atratone	Pebulate	<i>C-6989</i>
		WL 19805	Chlorpropham	<i>ACNQ</i>
		Atrazine	<i>Azinphosmethyl</i>	<i>Morestan</i>
		Simazine	<i>Diazinon</i>	<i>Isodrin</i>
		Ipazine		<i>Benomyl</i>
		Alachlor		<i>Dieldrin</i>
		Ametryne		<i>Chloroneb</i>
		Propazine		<i>Paraquat</i>
		Trietazine		<i>Trifluralin</i>
				<i>Benefin</i>
				<i>Heptachlor</i>
				<i>Endrin</i>
				<i>Aldrin</i>
				<i>Chlordane</i>
				<i>Toxaphene</i>
				<i>DDT</i>

Mobility decreases from 5 through to 1 and down the columns. Herbicides are typed in normal type; the remainder are insecticides, fungicides and acaricides.

Table 2: Relative mobilities of pesticides in soils.

Adsorption is the process whereby pesticide molecules in the soil become attached to soil colloids<sup>56</sup> through chemical bonds, the strength of which varies according to a variety of factors. It is perhaps the greatest single factor influencing mobility of pesticides in soils<sup>57</sup> and Weber and Weed<sup>58</sup> claim it to be a process directly influencing all other processes in the soil which involve the pesticide. Adsorption and desorption processes may influence the pesticide without a change in the molecule, and the result may be changed biological activity, or reduced mobility or volatility. Other surface reactions with or without other factors may lead directly to molecular change. Soil colloids, which are the agents of adsorption, may be inorganic (clay, iron and aluminium oxides) or organic (varying from substances only partly decomposed to completely altered and resynthesized compounds). The capacity of a colloid to adsorb pesticides is influenced by properties of the pesticide such as solubility in water, chemical structure, molecular size, volatility, and acid or base properties<sup>59</sup>. The biological consequences of adsorption are important, and they vary from effectively complete removal of pesticide from regions of potential biological activity (e.g., paraquat and diquat are bound very tightly by the clay, montmorillonite)<sup>60</sup>, through partial or nearly complete potential for biological interaction, depending on other factors such as soil pH<sup>61</sup>, moisture content and the type of colloid to which the pesticide is being adsorbed. Soil composition and type are, therefore, very important in determining pesticide mobility.

Volatilization is the third major fate which may befall a pesticide in the environment without involving change to the basic molecule. The tendency of a molecule to volatilize (or evaporate) depends, firstly, on factors in the environment such as temperature, adsorption, and air movement around the pesticide deposit, and secondly, on characteristics of the pesticide itself, such as its vapour pressure<sup>62</sup>.

#### 2.2.2 Fates involving chemical change

Pesticides distribute themselves between the biotic and abiotic (soil, water, air) segments when released into the environment, and if modification of the molecule occurs, it is generally irreversible<sup>63</sup>. The main changes are hydrolytic, oxidation and reducing, and in general, the chemical end-products are more polar (hydrophilic) than the original molecule<sup>64</sup>.

In the environment, the chemical similarity of, and the intermingling in small space of both biotic and abiotic reactions makes difficult the assessment of the relative importance of each. Clearly, however, abiotic reactions such as photodecomposition and hydrolysis will not proceed in the absence of light or water, respectively. A most important feature of chemical changes in the environment, is that they do not always result in reduced toxicity of the molecule, and in fact, the effective (desired) action of some compounds depends on an environmentally mediated increase in toxicity. Potential biological impact of a pesticide in the environment may largely be assessed by considering three questions relating to fate in the environment. Firstly, is the altered molecule sufficiently stable to be terminal? Secondly, do these terminal molecules have affinities which may result in biological magnification? And thirdly, is the terminal molecule capable of causing biological damage<sup>65</sup>?

- A. Non-biological transformations of pesticides are a result of photodecomposition, and other reactions which may or may not be mediated by the soil. Photodecomposition is due largely to the ultra-violet component of sunlight, and in general it is not considered a major cause of pesticide molecule breakdown<sup>66</sup>. Light energy absorbed by a pesticide molecule may be dissipated in a number of ways, and one is by molecular change. The first step is frequently molecular fission which results in production of a free radical<sup>67</sup> and this will generally react further in the immediate environment with such things as the solvent (usually water), other pesticide molecules or radicals, or other reactants in the soil, water, etc. The overall results of such a reaction may be isomerization, substitution<sup>68</sup>, or oxidation depending on the physical state of the pesticide, the solvent and the presence of other reactants such as oxygen<sup>69</sup>. Some substances which occur naturally in the environment, for example, ferric salts, riboflavin, rotenone and aromatic amines, are known to potentiate molecular decomposition of pesticides<sup>70</sup>. These molecules also may become energised by light, and can dissipate this energy through a neighbouring pesticide molecule<sup>71</sup>.

Dehalogenation<sup>72</sup> is a common consequence of photodecomposition, particularly among herbicides containing both chlorine and a benzene ring<sup>73</sup> (e.g., 2,4-D, 2,4,5-T). Among insecticides, DDT and

cyclodienes are susceptible to photodecomposition. (The cyclodiene group contains compounds, the toxicity of which is increased by photochemical action. The compounds involved are aldrin and dieldrin<sup>74</sup>.) Organophosphorus compounds exposed to light may undergo oxidation, cleavage, isomerization or polymerization<sup>75</sup>. Aromatic moieties<sup>76</sup> in pesticides, which are found in a number of pesticide groups (e.g., organophosphorus compounds, carbamates, phenoxyacetics, etc.) may undergo ring substitution, hydrolysis, oxidation or polymerization<sup>77</sup>. These so-called photonucleophilic reactions are both common and extensive, occurring wherever water and light occur together<sup>78</sup>.

Non-biological reactions involving neither light nor soil also occur. For example, among organophosphorus compounds, alkaline hydrolysis is very characteristic, but if it occurs in a strictly abiotic situation, it is relatively slow. Isomerization in organophosphorus compounds occurs<sup>79</sup> and oxidation is common among sulphur-containing compounds<sup>80</sup>.

Non-biological soil-mediated reactions are due largely to interaction of pesticide molecules and soil colloids, but metallic oxides and ions, organic compounds and surfaces also have a role. Soil colloids are particularly important because of the high concentration of hydrogen ions commonly surrounding them. These ions seem capable of taking part in a wide variety of chemical reactions, either as a catalyst<sup>81</sup> or by becoming part of the existing pesticide molecule. In all cases of reaction involving colloids, the ability of water to compete successfully with pesticide molecules for reactive sites on the colloid determines the ultimate reaction. Reactions in the soil may be mediated also by free radicals, metallic ions, hydrogen or hydroxyl ions, etc.<sup>82</sup>.

- B. Biological transformation of pesticides can be effected by a wide spectrum of living organisms. However, micro-organisms are frequently the major, and sometimes the only means by which pesticides are eliminated from a variety of ecosystems<sup>83</sup>. The types of micro-organisms involved are heterotrophic bacteria, fungi,

and actinomycetes, and they are very important in determining the persistence of a pesticide in the environment<sup>84</sup>. Higher plants are capable of degrading pesticides, but their action is generally slow, and their significance a result only of their relatively large total biomass<sup>85</sup>. The general result of metabolism by higher plants is conversion of the pesticide to some neutral water-soluble form which can be stored in cell vacuoles. Eventually, elements of the original molecule may be incorporated into structural parts of the plant<sup>86</sup>. Growth of both plants and micro-organisms is influenced by a number of environmental factors including soil or water pH, soil organic matter concentration, moisture content, temperature, cation-exchange capacity of the soil, and degree of aeration of the micro-environment. These various factors can be immediately recognized as factors which influence directly also the breakdown of pesticides.

In some situations, only biotic factors bring about chemical modification of a pesticide. In others, not even these factors produce chemical change, and this may be a result of physical inaccessibility, lack of appropriate enzymes, aerobic conditions rather than the 'preferred' anaerobic conditions, low solubility of the pesticide in water, or others. Alexander<sup>87</sup> suggests that the following conditions are necessary for microbial action on pesticides; all of these must be present: (i) an organism capable of metabolizing the pesticide must exist in the particular environment or be capable of living therein; (ii) the pesticide must be in a form suitable for degradation; (iii) the chemical must reach the organism, or the organism must be capable of finding its potential substrate; (iv) whilst in some cases, the appropriate enzyme exists, in others the compound must be capable of inducing formation of the appropriate enzyme or enzymes involved in transformation of the molecule; and (v) environmental conditions must be suitable for the micro-organism to proliferate and for the enzymes to function.

In the higher plants, the main reactions transforming pesticides are hydroxylation, oxygenation, reduction decarboxylation, N-dealkylation, conjugation and others<sup>88</sup>. In micro-organisms,

the principal actions are alkylation, dealkylation, amide and ester hydrolysis, dehalogenation, oxidation including dehydrogenation, reduction, ring and ether-bond cleavage, condensation and conjugation<sup>89</sup>. The more 'preferred' substrates for micro-organism action are outlined by Alexander<sup>90</sup> and Kaufman<sup>91</sup>.

The decomposition of a pesticide substrate by a micro-organism generally follows one of two general patterns: a time-independent interaction, or a time-dependent interaction<sup>92</sup>. In the first case, the rate of pesticide degradation bears little relationship to the passage of time, mainly because biological factors are unimportant. This response is evoked by such pesticides as arsenicals and others based on heavy metals which remain largely unchanged by microbial action and which are very persistent in the environment. The nature of the time-dependent decomposition is related to the value of the substrate to the micro-organism; where, for example, a micro-organism benefits from the energy derived from pesticide breakdown, after a period population will increase until the energy source is depleted, when it will decrease. These two growth phases are known as lag and enrichment, and where the same pesticide is applied later to the same soil, the delay apparent on the first occasion between the time of pesticide application and the commencement of breakdown, disappears. In other time-dependent responses, metabolic breakdown of the pesticide occurs, but the micro-organism derives little benefit from the breakdown. Either the micro-organism species involved has/have rather catholic tastes and derives no specific benefit from the pesticide, or the pesticide is co-metabolized, i.e., the enzymes for its breakdown are co-incidentally found in the micro-organism, but no benefit is derived from the particular reaction. In these latter cases, any response reflected in population change is related only to the relative concentration of the pesticide.

In this chapter, the undesirable potential effects of pesticides on living organisms including Man have been described, and also the various factors in the environment which alter, and perhaps completely destroy, their biological activity. Various methods



of disposal of surplus pesticides and their containers, and particularly those utilized by farmers, involve release of pesticide into the environment. The next chapter describes how all disposal methods aim to minimize undesirable effects on the natural environment, and how they often utilize selectively many of the features of the natural environment described above, to deactivate pesticides as quickly and completely as possible. The small number of industrial processes described below generally employ the same chemical reactions described above, but at a far higher rate.

NOTES

1. WARE, G. W., 1981; Effects of pesticides on non-target organisms, Residue Reviews 76, 173-201.
2. CARSON, R., 1963; Silent Spring; Hamish Hamilton, U.K.
3. See, for example:
  - a. EDWARDS, C. A., 1973; Persistent pesticide in the environment, p.1; C.R.C. Press, Inc., Ohio, U.S.A.
  - b. WHITTEN, J. L., 1966; That we may live; van Nostrand, New York, U.S.A.
4. See, for example:
  - a. BYRNE, J., 30 June 1979; Pact with Hell; Age, Melbourne.
  - b. JOHNSON, H. R. and G. P. EDWARDS (eds.), 1979; Pumpkins, poisons, and people; Conservation Council of Victoria, Melbourne, Australia.
5. See, for example, MOWBRAY, D. L., 1978; The ecological effects of pesticides on non-target organisms - a study of the environmental impact of pesticides on wildlife in the Namoi River Cotton Growing Area, 1972-1976; thesis submitted for the degree of Doctor of Philosophy, University of Sydney, New South Wales, Australia.
6. See, for example:
  - a. FREITAG, D., H. GEYER, W. KLEIN, A. G. KRAUS, E. LAHANIATIS and F. KORTE, 1979; An approach for comparative screening of the environmental behaviour of chemicals, Ecotoxicology and Environmental Safety 3, 144-151.
  - b. MORIARTY, F., 1977; Prediction of ecological effects of pesticides, in: Perring, F. H. and K. Mellanby (eds.), Ecological effects of pesticides, pp.165-174; published for the Linnean Society by Academic Press Ltd., London, U.K.
7. See, for example, TOMIZAWA, C. and H. KAZANO, 1975; Biological accumulation of pesticides in an ecosystem; evaluation of biodegradability and ecological magnification of pesticides by a model ecosystem, Review of Plant Protection Research 8, 41-54.

8. See, for example:
  - a. OLSEN, P. and H. SETTLE, 1979; Pesticide contamination of water rats in the Murrumbidgee Irrigation Areas, New South Wales, Australia, 1970-1972, Pesticides Monitoring Journal 12, 185-188.
  - b. DUNSMORE, J. D., L. S. Hall and K. H. KOTTEK, 1974; DDT in the bent-winged bat in Australia, Search 5, 110-111.
9. See, for example, OLSEN, P., H. SETTLE and R. SWIFT., 1980; Organochlorine residues in wings of ducks in south-eastern Australia, Australian Wildlife Research 7, 139-147.
10. See, for example, HASSETT, J. P. and G. F. LEE, 1975; Modeling of pesticides in the aqueous environment, in: Haque, R. and V. H. Freed (eds.), Environmental dynamics of pesticides, pp.173-184; Plenum Press, New York, U.S.A.
11. PIMENTEL, D., D. ANDOW, R. DYSON-HUDSON, D. GALLAHAN, S. JACOBSON, M. IRISH, S. KROOP, A. MOSS, I. SCHREINER, M. SHEPARD, T. THOMPSON and B. VINZANT, 1980; Environmental and social costs of pesticides: a preliminary assessment, Oikos 34, 126-40.
12. PIMENTEL, D., 1971; Ecological effects of pesticides on non-target species; Executive Officer of the President, Office of Science and Technology, U.S.A.
13. RUDD, R.L., 1964; Pesticides and the living landscape; University of Wisconsin Press, Wisconsin, U.S.A.
14. PERRING, F. H. and K. MELLANBY (eds.), 1977; Ecological effects of pesticides; published for the Linnean Society by Academic Press Ltd., London, U.K.
15. COPE, O. B., 1971; Interactions between pesticides and wildlife, Annual Review of Entomology 16, 325-364.
16. GUNN, D. L. and J. G. R. STEVENS (eds.), 1976; Pesticides and human welfare; Oxford University Press, U.K.

17. KENAGA, E. E., 1977; Evaluation of the hazard of pesticide residues in the environment, in: Watson, D. L. and A. W. A. Brown (eds.), Pesticide management and insecticide resistance, pp.51-95; Academic Press, New York, U.S.A.
18. BROWN, A. W. A., 1978; Ecology of pesticides; John Wiley and Sons Inc., New York, U.S.A.
19. The Co-ordinating Committee on Agricultural Chemicals comprises approximately fifteen members who are senior personnel representing a variety of government departments. The meeting was attended by delegates from the agricultural chemical industry, personnel from government wildlife, agricultural, national parks, health and other instrumentalities, as well as pesticide registration personnel.
20. Residues are the remnants of pesticide chemicals, changed or unchanged, which remain in plant, animal and other organisms, the soil, etc. Chemicals arising as a result of break-down of pesticides in living organisms are called metabolites.
21. ANON., undated; Co-ordinating Committee on Agricultural Chemicals Workshop on toxicity of agricultural chemicals to non-target native fauna, Canberra, 13-14 November 1980. Report. Document PB407. Pesticides Section, Department of Primary Industry, Canberra, Australia. Notes provided for delegates at this conference provide a good entry into the Australian literature.
22. BLOOM, H., W. TAYLOR, W. R. BLOOM, G. M. AYLING, 1979; Organochlorine pesticide residues in animals of Tasmania, Australia, Pesticides Monitoring Journal 13, 99-108.
23. ppm = parts per million.
24. BLOOM, H., et al, 1979; as Note 22.
25. MOONEY, N., National Parks and Wildlife Service, Tasmania, 1982; Personal communication.
26. a. STATHAM, H., 1982; Personal communication. This work will be published as below.  
b. STATHAM, H., (in press); Browsing damage in Tasmanian forests and effects of 1080 poison; Forestry Commission Bulletin, Forestry Commission, Tasmania.

27. ANON., undated; Report of the expert consultation on environmental criteria for registration of pesticides, held in Rome 25-29 June 1979. AGPP:MISC/34; F.A.O., Rome, Italy.
28. GIFAP AGRICULTURE COMMITTEE, 1980; Environmental criteria for registration of agrochemicals. Technical Monograph, No. 3, Groupement International des Associations Nationales de Fabricants de Produits Agrochimique, Brussels, Belgium. (The English title of this organisation, International Group of National Associations of Manufacturers of Agrochemical Products, is rarely used).
29. ANON., 1981; Pesticides: advice and recommendations to be used by national and other authorities as well as manufacturers concerned with the registration of agricultural and non-agricultural pesticides, pp.52-62; Fifth edition, Council of Europe, Strasbourg, France.
30. ANON., 1979; Pesticides Safety Precautions Scheme, agreed between Government Departments and Industrial Associations, Appendix D, Guidance on wildlife and environmental data requirements.
31. See, for example, MORGAN, D. P., 1980; Minimizing occupational exposure to pesticides: acute and chronic effects of pesticides on human health, Residue Reviews 75, 97-102.
32. Teratogenesis is the production, in the uterus, of offspring with physical defects.
33. Mutagenesis is the induction of genetic change in a cell, and in the present context, any change which takes place in germ cells may have a negative outcome in the following generation.
34. Morbidity is the ratio of sick people to well people in a community.
35. CAMPBELL, J.E., L. A. RICHARDSON and M. L. SCHAFER, 1965; Insecticide residues in the human diet, Archives of Environmental Health 10, 831-836.
36. HEYDE, T. E., National Poisons Information Service, Commonwealth Department of Health, 1981; Personal communication.

37. PARR, J. F., 1974; Effect of pesticides on micro-organisms in soil and water, in: Guenzi, W. D. (ed.), Pesticides in soil and water, pp.315-340; Soil Science Society of America, Inc., Madison, Wisconsin, U.S.A.
38. SIMON-SYLVESTRE, G. and J.- C. FOURNIER, 1979; Effects of pesticides on the soil microflora, Advances in Agronomy 31, 1-92.
39. BROWN, A. W. A., 1978; as Note 18.
40. EDWARDS, C. A. and A. R. THOMPSON, 1973; Pesticides and the soil fauna, Residue Reviews 45, 1-79.
41. ANDERSON, J. R., 1978; Pesticide effects on non-target soil micro-organisms, in: Hill, I. R. and S. J. L. Wright (eds.), Pesticide Microbiology, pp.313-533; Academic Press, Inc., London, U.K.
42. Nitrification is the conversion of ammonium ions ( $\text{NH}_4^+$ ) in the soil to nitrate ions ( $\text{NO}_3^-$ ): In terms of assimilation by plants of nitrogen, this process is very important.
43. Nitrogen fixation is the process by which atmospheric nitrogen is converted (ultimately) into a form of nitrogen suitable for assimilation by plants.
44. ANDERSON, J. R., 1978; as Note 41.
45. EDWARDS, G. A., 1973; as Note 3a., p.7.
46. See the following:
  - a. LETEY, J. and W. J. FARMER, 1974; Movement of pesticides in soil, in: Guenzi, W. D. (ed.), Pesticides in soil and water, pp.67-98; Soil Science Society of America, Inc., Madison, Wisconsin, U.S.A.
  - b. PITTER, R. L. and E. J. BAUM, 1975; Chemicals in the air; the atmosphere system and dispersal of chemicals, in: Haque, R. and V. H. Freed (eds.), Environmental dynamics of pesticides, pp.5-16; Plenum Press, New York, U.S.A.
47. Bulk density of the soil is the weight of dry soil per unit volume.

48. Porosity of the soil is the volume of air space in dried soil per unit volume of soil.
49. LETEY, J. and W. J. FARMER, 1974; as Note 46a.
50. As above. See also PITTER, R. L. and E. J. BAUM, 1975; as Note 46b.
51. See the following:
  - a. TARRANT, K. R. and J. O'G. TATTON, 1968; Organochlorine pesticides in rainwater in the British Isles, Nature 219, 725.
  - b. RISEBOROUGH, R. W., R. J. HUGGETT, J. J. GRIFFIN and E. D. GOLDBERG, 1968; Pesticides; transatlantic movements in the N. E. Trades, Science 159, 1233.
52. PETERLE, T. J., 1969; DDT in antarctic snow, Nature 224, 620.
53. SLADEN, W. J. L., C. M. MENZIE and W. L. REICHEL, 1966; DDT residues in Adelie penguins and a crabeater seal from Antarctica, Nature 210, 670-673.
54. MERKLE, M. G. and R. W. BOVEY, 1974; Movement of pesticides in surface water, in: Guenzi, W. D. (ed.), Pesticides in soil and water, pp.99-106; Soil Science Society of America, Inc., Madison, Wisconsin, U.S.A.
55. HELLING, C. S., P. C. KEARNEY and M. ALEXANDER, 1971; Behaviour of pesticides in soil, Advances in Agronomy 23, 147-240.
56. Soil colloids are those particles in the soil, the diameter of which is between 2 and  $200 \times 10^{-9}$  metre. ie 2-200 millimicron. See, for example, LEEPER, G. W. 1964; Introduction to soil science; Melbourne University Press, Melbourne, Australia.
57. LETEY, J. and W. J. FARMER, 1974; as Note 46a.
58. WEBER, J. B. and S. B. WEED, 1974; Effect of soil on the biological activities of pesticides, in: Guenzi, W. D. (ed.) Pesticides in soil and water, pp.223-256; Soil Science Society of America, Inc., Madison, Wisconsin, U.S.A.

59. See the following:
- a. WEBER, J. B. and S. B. WEED, 1974; as Note 58.
  - b. GREEN, R. E., 1974; Pesticide-clay-water interactions, in: Guenzi, W. D. (ed.), Pesticides in soil and water, pp.3-38; Soil Science Society of America, Inc., Madison, Wisconsin, U.S.A.
  - c. WEED, S. B. and J. B. WEBER, 1974; Pesticide-organic matter interactions, in: Guenzi, W. D. (ed.), Pesticides in soil and water, pp.39-66; Soil Science Society of America, Inc., Madison, Wisconsin, U.S.A.
60. WEBER, J. B. and S. B. WEED, 1974; as Note 58.
61. pH is a measurement of acidity or basicity.
62. Vapour pressure is a measure of the tendency of a substance to evaporate.
63. BROOKS, G. T., 1974; Chlorinated insecticides, Vol.II. Biological and environmental aspects; C.R.C. Press, Inc., Cleveland, Ohio, U.S.A.
64.
  - a. As above.
  - b. Hydrolytic chemical actions refer to chemical interaction with water which often involves splitting of a molecule. Oxidation and reduction refer to chemical processes involving addition and removal of oxygen and hydrogen atoms, among other things. Hydrophilicity is a measure of affinity for water.
65. MATSUMURA, F., 1972; Biological effects of toxic pesticidal contaminants and terminal residues, in: Matsumura, F., G. M. Boush and T. Misato (eds.), Environmental toxicology of pesticides, pp.525-548; Academic Press, Inc., (London) Ltd., London, U.K.
66. GORING, C. A. I., D. A. LASKOWSKI, J. W. HAMAKER and R. W. MEIKLE, 1975; Principles of pesticide degradation in soil, in: Haque, R. and V. H. Freed (eds.), Environmental dynamics of pesticides, pp.135-172; Plenum Press, New York, U.S.A.



67. Molecules are frequently made up of one or more functional groups or radicals. Free radicals, separated from the remainder of the molecule, are generally highly reactive and therefore rather transient in nature.
68. Isomerization refers to a rearrangement of atoms within a molecule without any compositional change. Substitution refers to mutual exchange of (usually) small parts of molecules, or reaction between an atom and a molecule, in which one atom is exchanged.
69. ARMSTRONG, D. E. and J. G. KONRAD, 1974; Non-biological degradation of pesticides, in: Guenzi, W. D. (ed.), Pesticides in soil and water, pp.123-132; Soil Science Society of America, Inc., Madison, Wisconsin, U.S.A.
70. See the following:
  - a. HELLING, C. S., P. C. KEARNEY and M. ALEXANDER, 1971; as Note 55.
  - b. MATSUMURA, F., 1975; Toxicology of insecticides, p.342; Plenum Press, New York, U.S.A.
71. HELLING, C. S., P. C. KEARNEY and M. ALEXANDER, 1971; as Note 55.
72. Dehalogenation is removal from a molecule of one or more atoms of chlorine, fluorine, bromine or iodine - most commonly in this context, of chlorine.
73. The benzene ring is a basic building block of organic compounds, and consists of a six-membered ring comprising six carbon atoms. This ring has been modified by man in a great number of ways.
74. HELLING, C. S., P. C. KEARNEY and M. ALEXANDER, 1971; as Note 55.
75.
  - a. ETO, M., 1974; Organophosphorus pesticides: organic and biological chemistry; C.R.C. Press, Inc., Cleveland, Ohio, U.S.A.
  - b. Cleavage refers to splitting of a molecule, generally between functional groups. Polymerization refers to formation of so-called macro-molecules by the joining of many smaller molecules end-to-end to form branched or unbranched chains.

76. Aromatic moieties are the benzene ring components of organic compounds. See also Note 73.
77.
  - a. MATSUMURA, F., 1975; as Note 68b.
  - b. Ring substitution refers to exchange of atoms or groups attached to a benzene ring.
78. MATSUMURA, F., 1975; as Note 70b.
79. For example, thiono-sulphur, =S, may be converted to thiolo-sulphur, -S-.
80. See the following:
  - a. HELLING, C. S., P. C. KEARNEY and M. ALEXANDER, 1971; as Note 55.
  - b. ETO, M., 1974; as Note 75a.
81. A catalyst is a substance which enhances a chemical reaction without itself being chemically changed by the reaction.
82. See the following:
  - a. HELLING, C. S., P. C. KEARNEY and M. ALEXANDER, 1971; as Note 55.
  - b. GREEN, R. E., 1974; as Note 59b.
83. ALEXANDER, M., 1972; Microbial degradation of pesticides, in: Matsumura, F., G. M. Boush and T. Misato (eds.), Environmental toxicology of pesticides, pp.365-384; Academic Press, New York, U.S.A.
84. As above.
85. MATSUNAKA, S., 1972; Metabolism of pesticides in higher plants, in: Matsumura, F., G. M. Boush and T. Misato (eds.), Environmental toxicology of pesticides, pp.341-364; Academic Press, New York, U.S.A.
86. CROSBY, D. G., 1973; The fate of pesticides in the environment, Annual Review of Plant Physiology 24, 467-492.
87. ALEXANDER, M., 1966; Biodegradation of pesticides, in: S. Breth, (ed.), Pesticides and their effects on soils and water, pp.78-84; Soil Science Society of America, Inc., Madison, Wisconsin, U.S.A.

88. a. MATSUNAKA, S., 1972; as Note 85.
- b. Hydroxylation refers to the addition of a hydroxy(l) group (-OH) to the pesticide molecule. Decarboxylation and dealkylation refer to removal from the molecule of a carboxy group (-COOH) or of a group formed by a carbon chain. Conjugation describes the joining of the pesticide molecule (or part of it) to another compound or chemical group.
89. a. KAUFMAN, D. D., 1974; Degradation of pesticides by soil micro-organisms, in: Guenzi, W. D. (ed.), Pesticides in soil and water, pp.133-202; Soil Science Society of America, Inc., Madison, Wisconsin, U.S.A.
- b. Alkylation refers to addition to the pesticide molecule of groups based on a carbon chain. Condensation refers to the joining of two molecules together with the simultaneous release of a molecule of water or another simple molecule.
90. ALEXANDER, M., 1966; as Note 87.
91. KAUFMAN, D. D., 1974; as Note 89a.
92. HILTBOLD, A. E., 1974; Persistence of pesticides in soil, in: Guenzi, W. D. (ed.), Pesticides in soil and water, pp.203-222; Soil Science Society of America, Inc., Madison, Wisconsin, U.S.A.



## CHAPTER 3

### DISPOSAL OF PESTICIDES AND CONTAINERS

This chapter outlines the magnitude of problems associated with pesticide and pesticide container disposal, and also the environmental principles underlying the need for disposal. The situations demanding disposal action are described, followed by a review of the methods of disposal. Comment is made on both the favourable and unfavourable consequences of disposal, and the questions of cost and the law are briefly examined. The basic aim of this document is to examine the issue of pesticide and container disposal by the farmer, and this perspective is emphasized throughout. However, it is important to note from the outset, that pesticide wastes generated by the manufacturer are a greater problem than those accumulating on farms. For two reasons, this chapter makes little reference to the Australian and Tasmanian situations: firstly, very little has been published in Australia about the topic<sup>1</sup>, and secondly, it seems more appropriate to examine the local situation in Chapter 4 where the farmer survey, carried out as part of this project, is analysed.

#### 3.1 MAGNITUDE OF THE DISPOSAL PROBLEM AND REASONS FOR DISPOSAL

The preceding chapter outlines in a general way the potential hazards posed by pesticides to humans and other life forms. The dangers specifically associated with waste pesticides and containers are brought into sharper focus in this section.

Estimates have been made in the United Kingdom, the United States and Australia of the quantities of waste pesticides generated in each country. Unfortunately, the basis of calculation of each does not allow a direct comparison. In Britain, the British Agrochemicals Association estimated that less than 300 tonnes of active ingredient was disposed of away from the premises of manufacturers and formulators in 1977<sup>2</sup>. No comment about on-site disposal was made. Each year, the (British) Ministry of Agriculture, Fisheries and Food conducts a survey of pesticide use among English and Welsh

farmers, and simultaneously makes an approximate assessment of waste pesticides on the farm awaiting disposal. Between the years 1965 and 1979, the percentage of sampled farms holding pesticide for disposal varied from 4.3% to 14.4%<sup>3</sup>. The quantities held were not mentioned.

In the United States, a number of estimates have been made of the pesticide wastes generated. Among these estimates are: (i) 10% of all pesticide produced in the United States<sup>4</sup> (In 1976, total production of active ingredient in the United States was about 750,000 tonne); (ii) 100 million U.S. gallons of dilute pesticide, at or below recommended tank-mix<sup>5</sup> concentration, coming from container and equipment rinsing<sup>6</sup>; (iii) 125 million U.S. gallons of the same<sup>7</sup>; and (iv) 500 tonne of active ingredient as rinsate from containers, largely on the farm<sup>8</sup>. No estimate could be found of quantities being held on farms for disposal<sup>9</sup>.

In Australia, the only estimates which could be found appeared in recent surveys, and were 120 tonne of solid pesticide<sup>10</sup> and 19,000 litre of liquid<sup>11</sup>, none or little of which would have been generated on farms. Both of these estimates are considered very conservative<sup>12</sup>.

Estimates of the numbers of pesticide containers produced annually (which, over a period of time, would be the same as the number emptied) have been more common than of waste pesticide, and may well be more accurate. In the United Kingdom, the Seventh Report of the Royal Commission on Environmental Pollution which dealt with agriculture<sup>13</sup> noted that approximately 1½ million 25 litre drums were sold annually to farmers in Great Britain. Sales of other sizes of container were not mentioned.

In the United States, a number of estimates of container numbers have been made over a period of time<sup>14</sup> and these vary from 91 million up to 240 million both estimates in 1966. Estimates of the relative proportions of different container-types have been made<sup>15</sup> as well as estimates for different individual states<sup>16</sup>. Münneke<sup>17</sup> extrapolated from earlier estimates to an annual world-wide container use of between 600 million and 1,100 million. The only known estimate for Australia assessed 'production' of containers by home gardeners at more than approximately 2.6 million<sup>18</sup>. The author's estimate of container generation by Tasmanian farmers, given below, is the only known estimate of its type in Australia.

The principal generators of pesticide wastes are pesticide manufacturers, pesticide formulators, distributors, retailers, professional applicators, industrial users of pesticides, cooperage (drum making and reconditioning) facilities, government bodies, home gardeners, transport and storage groups, and farmers<sup>19</sup>. The potential or actual hazards, whether in the form of stored pesticides, or as pesticides released into the environment as leaks, industrial wastes, container and equipment rinsate, etc., have been described in Chapter 2, and follow classical toxicological principles, i.e. the outcome is dependent on the organism involved, the exposure situation and the many variables relating to the pesticide<sup>20</sup>. Exposure of any type, therefore, is potentially harmful, but for example, due to interspecific and situational differences, exposure to container rinsate of clothed humans, fish in a nearby stream and soil micro-organisms may have anything from negligible, through transient to fatal effects.

Whilst the same basic principles apply to pesticides in containers, they do represent a special case which requires comment. A number of papers highlighting the fallacy of the empty pesticide container have been published, and residues remaining in dumped 5 gallon drums. as high as nearly 50%<sup>21</sup> and as low as 0.8% of filled volume<sup>22</sup> have been reported. Laboratory studies of partly controlled container drainage have shown that drums of 1, 5, 30 and 55 (U.S.) gallons of parathion and 2,4-D may leave residues varying from 0.37% (for 1 gallon drums) to 0.04% (for 55 gallon drums) of total volume<sup>23</sup>. Further research showed that 30 and 55 (U.S.) gallon drums left average residues of 39 g of phorate and 18.8 g of disulfoton after 'emptying'. Residues of malathion and 2,4,5-T remaining in 5 gallon drums were also examined<sup>24</sup>. Wolfe<sup>25</sup> discusses residues of parathion remaining in paper bag packaging. In all of these cases, a consideration of the quantity of pesticide remaining in relation to its degree of toxicity emphasizes the potential dangers involved. Gehlbach<sup>26</sup> presented a number of case histories of pesticide poisoning which resulted directly from storage in incorrect containers, and cited more than one case where inadequate disposal had unwanted consequences. The point is also made, that pesticide containers thought to be empty, can be as dangerous as full containers.

### 3.2 METHODS OF PESTICIDE AND CONTAINER DISPOSAL

Traditionally, the farmer is a relatively frugal being, and when he buys pesticide, there are normally specific plans for it. On the surface, it seems rather paradoxical, therefore, that a need for disposal should ever arise. Situations making disposal of concentrated pesticide necessary include suspension or banning of sale of a pesticide, increasing unpopularity of a pesticide with farmers, contamination of packaged pesticide, leaking pesticide containers, stockpiling which has occurred for different reasons, sudden increase in a target's resistance to a compound or class of compounds, the appropriate crop is no longer grown, or the chemical has become old and is perhaps no longer effective<sup>27</sup>. The necessity for disposal of both tankmix pesticide and pesticide containers is clear: the purchase of pesticides always brings with it the purchase of pesticide containers. All but the worst of farmers will generate pesticide rinsate from the cleaning of spray equipment, etc., and very few farmers will not, at one stage or another, have found himself with surplus tankmix.

#### 3.2.1 Pesticides

This examination of methods of disposal of waste pesticides considers principally techniques appropriate for the farmer, but looks also at some other techniques which may have other application in Tasmania. A general perusal of the literature shows the close links which exist between disposal of hazardous industrial waste<sup>28</sup>, decontamination of soil and water<sup>29</sup>, solid industrial and municipal wastes<sup>30</sup>, and the fate of pesticides in the environment in general<sup>31</sup>. The area of industrial hazardous waste disposal has probably made the greatest 'outside' contribution to the knowledge on pesticide disposal, and this stems from two reasons: firstly, industrial hazardous waste is a far greater problem than pesticide wastes, and therefore is the subject of greater research effort. Secondly, there is some commonality of problems (e.g., mercurials, arsenicals, chlorophenols, polychlorinated biphenyls and solvents are some groups of hazardous chemicals common to both industry and agriculture) and appropriate disposal techniques. In general however, industrial techniques have little application to farm disposal.

Notable in the English language literature is the negligible contribution from countries other than the United States, and this is exemplified in



recent publications by the British Department of the Environment<sup>32</sup>, and the Council of Europe<sup>33</sup>, where almost all referenced original and scientific publications relating to pesticide disposal were ultimately of United States origin. Perusal of recent abstract journals<sup>34</sup> however, reveals publications on Swedish disposal research<sup>35</sup>, and a small number of German contributions. Because major pesticide manufacturers are situated in Great Britain, West Germany and Switzerland among others, it seems likely that a considerable repository of knowledge of disposal methods would exist in Europe, at industrial levels at least. One possible explanation of this anomaly is the more open philosophy of the United States towards information, particularly in areas involving safety, and probably also the wide-ranging activities of large organizations in the United States such as the Environmental Protection Agency and the Department of Agriculture.

Another feature of the literature was the relatively high proportion which was found in publications which were not a part of any series, or of any longer term research effort; this caused some difficulty in obtaining literature.

Four recent reviews have greatly facilitated access to the literature and existing knowledge on aspects of disposal<sup>36</sup>. In particular, the reviews by Lawless et al, Guidelines for the disposal of small quantities of unused pesticide<sup>37</sup>, and by SCS Engineers, Disposal of dilute pesticide solutions<sup>38</sup> are of relevance to the farm situation. Three of these have, in fact, been brought under the one cover in largely unchanged form<sup>39</sup>, and further general reviews exist<sup>40</sup>. The review by Little et al<sup>41</sup>, whilst having an economic bias, is useful as a general review. These reviews are strictly scientific in style and content, but beyond them is a considerable number of papers, articles, codes, booklets, etc., of differing standards which are aimed largely at the farmer or home gardener. These are discussed later in this chapter.

The latest review of disposal methods by Münnecke<sup>42</sup> classifies techniques into chemical, physical and biological - a classification at variance with that of Wilkinson<sup>43</sup>. However, categorization is largely arbitrary and of little significance:

- a. *Chemical detoxification and disposal methods* include hydrolysis, oxidation, reduction, fixation, solvent extraction, adsorption or chlorinolysis. Most studies of acid and base hydrolysis and oxidation and reduction have been concerned mainly with tankmix pesticides and rinsates. The other chemical approaches such as precipitation, chlorinolysis, neutralization and ion exchange have greater industrial application<sup>44</sup>. Further sophisticated chemical approaches include ozonation, molten salt processes, and catalytic dechlorination<sup>45</sup>.
- b. *Physical detoxification and disposal methods* include land- and ocean-based incineration, deep well injection and ground burial, photolysis and microwave plasma destruction<sup>46</sup>.
- c. *Biological detoxification and disposal methods* include soil incorporation, landfills, activated sludge systems and enzymatic treatment<sup>47</sup>.

For the reader interested in methods of disposal which have no application to the farm situation, the reviews by Münnecke<sup>48</sup> and Wilkinson et al<sup>49</sup> are good starting points. The remainder of this chapter is directed mainly towards those methods of disposal most suited to the farm situation, firstly because the farm situation is the main concern of this project, and secondly, because there is no known manufacture or formulation in Tasmania. However, because a communal approach may ultimately be best for some aspects of disposal, there is some discussion of larger scale techniques also.

In general, the method of disposal chosen depends upon the quantity for disposal, the chemical and biochemical degradability of the active ingredient, concentration and toxicity of the active ingredient, physical form of the waste, legal requirements of the disposal process, cost of the treatment or disposal facilities, and the availability of disposal routes<sup>50</sup>. Disposal methods adopted on farms depend on a different and smaller spectrum of considerations: facilities available and proximity of the intended site to nearby communities, crops, streams and other geological or environmental considerations<sup>51</sup>. There is need for an option when selecting a method of disposal because no single means exists which is suitable for all pesticides.

It has already been stated that the ultimate aim of disposal is to render pesticides permanently harmless to all life-forms. Where this is not possible, the compromise solution must stress containment and where possible, volume reduction<sup>52</sup>. Lawless et al<sup>53</sup> suggest the following environmental considerations for disposal on the farm: (i) potential for damage to water quality should be minimized, preferably well below any legally established limits of pollution; (ii) contributions to the problems of air pollution and solid waste disposal should be minimized, particularly where incinerating or burning; (iii) pesticides should be degraded to a biologically inactive form - a difficult or maybe impossible goal for the farmer. Alternatively, the most undesirable feature of the compound should be modified; for example, a highly toxic pesticide should be made less toxic, or a pesticide with a tendency for bio-magnification should be rendered non-accumulative, etc.

Lawless et al<sup>54</sup> discussed also a number of practical limitations which the farmer must overcome when wishing to dispose of a pesticide. The generally reasonable assumption is made that, in the context of chemicals, the farmer is a layman. If these practical and knowledge limitations are taken together, they define the line between those methods suitable for on-farm use, and those which are unsuitable. Firstly, it is clear that the farmer has limited equipment with which to handle disposal; he has a limited number of suitable chemicals to use, and he also has limited access to them; he has limited experience with chemical reactions, or the incineration of chemicals; and finally, a good rule-of-thumb to adopt is that any chemical reaction used should not involve greater risk than when handling the product according to manufacturers' instructions. In general, these guidelines seem appropriate for the Tasmanian (and Australian) situation, and so the methods which will be considered for farm application are: non-disposal, burning, acid or alkali hydrolysis, chemical oxidation or reduction, burial, ground surface disposal, dilution and release to the air. Other methods not suitable for the farm, but perhaps having some application in Tasmania, are also discussed. These include incineration, evaporation basins, trickling filters, disposal with sewage, and others. In proposing the methods first named above (non-disposal, etc.) as being essentially appropriate for farm application, it should be pointed out that in the United Kingdom<sup>55</sup>, the U.S.<sup>56</sup>, Australia<sup>57</sup>, and the European Economic Community countries<sup>58</sup>, only a limited number of recommendations are

currently made for farmers and on-farm disposal. These are: dilution and spraying onto paddocks<sup>59</sup>, incorporation into the soil plough layer, or chemical deactivation<sup>60</sup>, dilution and burial in a pit with lime<sup>61</sup>, or disposal into a soil- and gravel-containing concrete lined pit<sup>62</sup>. In general, incineration is discouraged and little information is available for the farmer. Wilkinson et al<sup>63</sup> identified 55 pesticides as 'problem pesticides' in the context of disposal, and these are shown below. The problems have their origins in potential effects on human health, ecological concerns, or specific, widely reported incidents.

Pesticide Classification	Problem Pesticides
Inorganic and metallic-organic pesticides:	organoarsenicals and organomercury compounds, PMA, thallium sulfate
Phosphorus-containing pesticides:	DDVP, DEF®, dimethoate, EPN, leptophos, merphos, ronnel, trichlorfon
Nitrogen-containing pesticides:	amitraz, benomyl, captan, carbaryl, diallate, kaybam, maleic hydrazide, maneb, monuron, nabam, paraquat, pronamide, triallate, zineb
Halogen-containing pesticides:	aldrin, BHC, chloranil, chlordane, chlordecone, chlorobenzilate, chloroform, DBCP, DDT, dieldrin, endrin, ethyl DDD, ethylene dibromide, heptachlor, Herbicide Orange, lindane, mirex, methoxychlor, monocrotophos, PCNB, PCP, 2,4,5,-T, toxaphene, trichlorfon
Sulfur-containing pesticides:	Aramite®
Botanicals and microbiological pesticides:	strychnine
Organic pesticides, not elsewhere classified:	Compound 1080, creosote, ethylene oxide, piperonyl butoxide

Table 3: Problem pesticides for disposal

Both Wilkinson et al<sup>64</sup> and Lawless et al<sup>65</sup> referred to the problems associated with mixed pesticides: namely, the combination of chemically or environmentally different active ingredients, and the paucity of knowledge on appropriate disposal measures.

Before commencing a detailed discussion of disposal methods, it bears reiteration that pesticide disposal must take account of the pesticide involved, who is responsible for its disposal and what hazards are involved, to mention a few considerations. Further, there are several types of pesticide with differing disposal characteristics, the circumstances of disposal vary greatly as does also the knowledge and imagination of the user, the location of, and geological terrain around the disposal site. One solution for all situations does not, therefore, exist<sup>66</sup>.

The two sections which follow examine, firstly, the general literature relating to disposal of pesticides, and secondly, the various recommendations made for disposal on the farm or by the farmer.

## I. General Overview

- A. Non-disposal or reduction of waste pesticide accumulation is the most preferred approach in most on-farm situations. This involves giving the waste pesticide to a responsible farmer who will use the pesticide for its normal, intended purpose. Alternatively or additionally, purchase only of the amount required, or preparation as tankmix of the amount required can reduce the quantity of waste. Where some tankmix does remain unused, small areas can be resprayed or a small additional area could be sprayed. Thorough rinsing of empty containers reduces residues remaining on the farm<sup>67</sup>. Other possible approaches not involving on-farm disposal include consignment of wastes to a pesticide collection centre<sup>68</sup>, to waste disposal contractors<sup>69</sup>, or if unopened, to a supplier<sup>70</sup>. For readers interested in an emotional, intemperate and ill-informed defence of non-disposal, a paper by McDonald<sup>71</sup> is high priority reading.

- B. Incineration or burning are both, in general, discouraged as a means of on-farm disposal, principally because the average farm incinerator does not reach the temperatures normally necessary for complete destruction of a pesticide. However, incineration is an established means for disposal, and could have application in Tasmania or Australia for larger quantities of pesticide where government agencies become involved. In the United States, incineration has probably been the method most used for disposal of large quantities of pesticide (e.g., 2.3 million gallons of Agent Orange<sup>72</sup> and large quantities of Kepone<sup>73</sup>).

A variety of incinerators can be used for this type of disposal<sup>74</sup>, and most commonly employed have been rotary kilns and liquid injection incinerators<sup>75</sup>. The main problem has been maintenance of temperatures adequate for the destruction down to simple molecules of all by-products produced. Among the by-products can be carbon dioxide, carbon monoxide, water, sulphur dioxide, nitrogen dioxide, hydrogen cyanide, phosgene, hydrogen chloride, oxides of phosphorus, chlorine and others, and some of these must be removed by scrubbing. The Environmental Protection Agency in the United States has established that a temperature of 1000°C combined with a dwell (exposure) time of two seconds and an adequate supply of air is adequate for 99.9% destruction of organic pesticides. For metal-containing pesticides (arsenicals, mercurials, and others) and inorganic pesticides, incineration is not recommended. Whilst disposal by incineration is reliable, predictable and versatile<sup>76</sup>, economically it is capital- and energy-intensive and is therefore suitable only for large scale use, i.e., 'tonnage' operations. It is unsuited to the small batch operations of most consumer and field disposal type problems<sup>77</sup>.

Burning is, in effect, low temperature incineration, and describes the abilities of the average farm 'incinerator'. Lawless et al<sup>78</sup> describe burning as a suitable method for farm disposal for certain pesticides of relatively low toxicity.

However, the Environmental Protection Agency in the United States<sup>79</sup>, and standard recommendation in Australia<sup>80</sup> suggest that the farmer does not burn any pesticides, whilst European<sup>81</sup> and British<sup>82</sup> recommendations make no mention of farm burning. Three relatively early papers<sup>83</sup> report experiments examining the fates of pesticides subjected to a range of temperatures, and in many cases temperatures of less than 400°C produced some degree of degradation. Similar results may reasonably be expected from farm burning, but inadequate knowledge of the products of such combustion make desirable further research in this direction.

- C. Chemical methods of disposal - hydrolysis, reduction and oxidation: four publications in particular consider possible methods of disposal suitable for the farmer, which use chemicals<sup>84</sup>. Lawless et al<sup>85</sup> consider a variety of methods for disposal of small quantities of pesticide, and include chemical means as one overall option. For reasons of safety, however, it is suggested that the chemical treatments are carried out in a soil pit, rather than in solution in a container as suggested by Shih and Dal Porto<sup>86</sup>. The final list of 18 pesticides from Shih and Dal Porto<sup>87</sup> and Lande<sup>88</sup> which are susceptible to alkaline treatment with caustic soda, was compiled on the basis of an extensive literature survey and discussions with pesticide manufacturers. They surveyed acid and alkaline hydrolysis and reduction and oxidation. Reagents considered had to be cheap, readily available, free of fire hazard or effect on fish or mammals, and they included concentrated and dilute strong acids and alkalis, hypochlorite solutions, sodium iodide, metals, sulphide, cyanide, acetone, acetate and others. For methods to be acceptable, the degree of degradation, and the identity of degradation products or their potential for causing environmental damage or posing other types of hazard had to be known, and the reagents had to be cheap. From a variety of tests on a total of 60 pesticides, alkaline hydrolysis was the only method selected, and it was judged suitable for only 18 pesticide active ingredients:

naled*	atrazine*	methamidophos
diazinon*	monocrotophos	methyl parathion
azinphos-methyl*	phosphamidon	carbofuran
maldison*	fensulfothion	aldicarb
carbaryl*	disulfoton	methomyl
captan*	phorate	captafol

\* See Note 89.

Table 4: Pesticides suitable for degradation by alkaline hydrolysis

The following preparations were judged unsuitable for degradation by the method of alkaline hydrolysis, for the reasons given:

fenchlorphos	diuron	dursban*
dimethoate	dyanazine	maneb*
dyfonate	chlorobenzilate	alachlor*
DEF	DBCP	picloram*
EPTC	D-D	trifluralin*
molinate	sodium fluoroacetate	methoxychlor*
propanil	warfarin	chlordane*
diphenamid	lindane	toxaphene*
simazine	paraquat	amiben*

\* See Note 90.

Table 5: Pesticides unsuitable for degradation by alkaline hydrolysis.

Lawless et al<sup>91</sup> examined 550 pesticides, and found 80 pesticides which they believed suitable for disposal by laymen using chemicals. Of these 80, alkaline hydrolysis was the most favoured method for 60, for 13, acid hydrolysis was best, and for six, oxidation. Compounds for which acid hydrolysis is an option are listed on the next page:



bensulide	dithane	schradan
CDEC	ferbam	sodium isopropyl xanthate
chlorobenzilate	maneb	thiram
dazomet	metham	tropital
2,4-DEP	nabam	zineb
dimefox	niacide	ziram

Table 6: Pesticides suitable for deactivation by acid hydrolysis.

Münnecke<sup>92</sup> pointed out that the recommendations of Shih and Dal Porto<sup>93</sup> and Lande<sup>94</sup> imply a similarity of degradation rates in diluted and undiluted pesticides, and that this is not true. Interesting also is the disagreement between Lawless et al<sup>95</sup> on the one hand, and Shih and Dal Porto<sup>96</sup> and Lande<sup>97</sup> on the other about which active ingredients are suited to disposal by alkaline hydrolysis. However, it may be argued that the use of a pit for chemical degradation overcomes the problems seen by Shih and Dal Porto<sup>98</sup>.

In the application of chemical disposal methods, SCS Engineers<sup>99</sup> see the advantages of predictability and separation from the environment. However, there are also potential disadvantages such as incomplete detoxification, production of compounds which are more toxic, and the small problem of determining what quantity of deactivating agent is required.

- D. Biological methods of disposal embrace methods employing the soil as well as evaporation basins, trickling filters and techniques using bacteria. The approaches to biological disposal have been based, to a significant degree, on studies of pesticide runoff in agricultural situations. The large number of variables involved, already mentioned on several occasions, make questionable the validity of using such data as a basis for disposal recommendations, and in fact, even controlled laboratory trials have limited application to such

disposal methods as landfill. Future research needs to examine real situations, integrated systems (which use more than one of the established methods) and a wide selection of pesticides<sup>100</sup>.

*Land disposal* is generally characterized by its cheapness, the availability in rural areas of the requisite equipment and personnel, and its simplicity and effectiveness<sup>101</sup>. The basic mechanisms which operate to make landfill disposal satisfactory are partly physical (immobilization, volatilization, adsorption), and partly chemical (photodecomposition, catalysed hydrolysis, oxidation), but largely biological (microbial degradation). The relative importance of these various factors varies from site to site, and is difficult to determine. However, the most important would be microbial action, volatilization and adsorption<sup>102</sup>. Land disposal methods take several forms:

- a. land cultivation and landfill have many features in common and both are suited to use by the farmer, although perhaps not on the farm. Land cultivation of surplus pesticides involves placement of either dilute or concentrated pesticide in the plough layer of a paddock. Application may be by a normal mobile spray or by spray irrigation, after which the pesticide is disced into the soil. Alternatively, application may be by subsurface injection, a technique which minimizes volatilization<sup>103</sup>. SCS Engineers<sup>104</sup> suggest that an area should be set aside for this specific use, and there should be berms and drains at the edges as well as a sump where pesticide-containing runoff could be contained. Until further information becomes available, Marsh et al<sup>105</sup> suggest application at a rate per hectare the same as recommended for normal use.

Sanitary landfill is defined by the American Society of Civil Engineers as:

*a method of disposing of refuse on land without creating nuisance or hazards to public health or safety, by utilizing the principles of engineering to confine the refuse to the smallest practical area, to reduce to the smallest practical volume, and to cover it with earth at the conclusion of each day's operations, or at such more frequent intervals as may be necessary.*

This involves preparation of a trench or excavation in which refuse is spread and compacted in several successive thin layers which are then covered with earth which is compacted daily. This approach is thought better than an open pit because of the reduced access to mobile life forms due to fences, the cover, etc.<sup>106</sup>. Potential problems include contamination of surface and groundwater, particularly where continuous or even intermittent contact between refuse and ground-water occurs. Selection of site is therefore important. Noting that there is a relative wealth of information on the engineering aspects of landfill, Ghassemi et al<sup>107</sup> examined the social, economic, political and institutional aspects of seven landfills in the United States which accept pesticides. Their survey discussed, in comparative tabular form, 20 aspects including the impetus which led to establishment, the operating agencies, costs and their payment, treatment and disposal methods, risks, etc.

Novak et al<sup>108</sup> set out the points to be considered when establishing a landfill (or equally, a pit on the farm): (i) the land should be relatively high and flat, or gently sloping away from any water supply that could conceivably be used for domestic purposes; (ii) soil should be deep, with at least 8-10 feet (2½-3 metres) from the surface to the lower level of downward leaching or percolation of water, before encountering bedrock or hardpan where movement is lateral. The site should be 50 feet (15 metres) and preferably 100 feet (31 metres) from water; (iii) the site should be selected where

there is no likelihood of other uses (e.g., cropping, grazing, building); (iv) the site should be prepared well in advance of use, and should be fenced and sign-posted, and, (v) the location should be convenient for access and suitable for pesticides and containers, and perhaps other less hazardous waste.

SCS Engineers<sup>109</sup> extend this list by pointing to the need for freedom from flooding, and to siting where soils most conducive to degradation or retention are found<sup>110</sup>. Erosion potential should be small, and rainfall low to prevent development of an anaerobic mire<sup>111</sup>. Moore<sup>112</sup> and the Working Group on Pesticides<sup>113</sup> also describe the ideal conditions for a disposal site. Clearly, monitoring of such a site for seepage, etc., is desirable<sup>114</sup>.

- b. pits and mounds for disposal involve three principle techniques. Whilst both pits and mounds techniques involve soil disposal, 'pits' has acquired two meanings in the context of pesticide disposal. Firstly, and in fact closely allied in general principles to landfill disposal, is the simple hole in the soil into which pesticides (with or without containers) are thrown without further attention such as immediate covering. Flammable materials, which by design or otherwise may include pesticides, may be burnt to reduce volume. This method is cheap and simple, the pits are easily constructed and maintained, and dilute or concentrated pesticides may be disposed of. However, on the farm, such pits are generally located with little regard to local geological structures or groundwater. Frequently abandoned pits or gullies are used which are permanent or intermittent water courses, and burning may be incomplete<sup>115</sup>.

Secondly, there is the man-made concrete, plastic or other type of pit. Since 1977, the Environmental Protection Agency in the United States has been funding only one project on methods of pesticide disposal, namely, a project being carried out at Iowa State University. The final report of this project<sup>116</sup> has only recently become available and only a short comment on this valuable contribution is possible. The investigation was aimed at providing safe disposal methods for private pesticide users, and it assessed the performances of a covered gravel- and soil-filled pit lined with concrete, and a polyethylene-lined pit. The concrete-lined pit received mixed surplus pesticides from routine farm spraying at random intervals, and this construction in particular showed itself highly effective as a method of pesticide detoxification<sup>117</sup>, and also free of undesirable environmental effects. Microbial growth in this pit was studied by Johnson et al<sup>118</sup> but only general conclusions could be drawn, and evidence suggesting that the breakdown of the pesticides was microbial, was only indirect. Work carried out at the University of California<sup>119</sup> involved a plastic-lined pit filled with soil mounds, but relatively little is known at this stage of the efficacy of this method. Advantages of such systems are their compactness, the containment of the pesticide at the use site, and the potential for location at a variety of sites. However, in comparison with other methods, the cost may be seen as a disadvantage, and the longevity of the systems (i.e., the time elapsing before complete replacement of the soil and gravel is necessary) is not yet known<sup>120</sup>. Furthermore, there seems to have been no assessment of the ability of these systems to assimilate pesticide concentrates. A further contribution to pesticide disposal pits has been made in Tasmania by Gillham<sup>121</sup>. This device has been designed for disposal of spent sheep dip, and is discussed below.

*Other biological methods* for disposal of pesticides include trickle filters and activated sludges. The disadvantages of these devices include their complexity, the need for specific operating conditions and trained personnel. Furthermore, these systems are very sensitive to variations in pH, temperature, nutrient content and chemical structure of the pesticide<sup>122</sup>. Nevertheless, Wilkinson et al<sup>123</sup> make recommendation for future research on both activated sludge and trickle filters. Recent research has considered the role which sewage<sup>124</sup> or composting in a mixture of cattle manure and sawdust<sup>125</sup> could play in pesticide disposal. In both cases, research was in the preliminary stages, but degradation was appreciable.

A further area of development in biological research is the utilization of mutant bacteria for the chemical breakdown of pesticides, and this general approach has gained added momentum from the current interest in genetic engineering techniques. Phenobac® is a freeze-dried biochemical preparation containing mutant bacteria mixed with a growth-enhancing substrate. Designed primarily to degrade a range of industrial products, some experiments on pesticide degradation have been sufficiently successful to warrant further research<sup>126</sup>. In the only known Australian scientific contribution to the whole subject of pesticide disposal, Pemberton<sup>127</sup> and Pemberton and Don<sup>128</sup> point to the possibility of reducing environmental pollution by pesticides by utilizing bacterial strains having pesticide-degrading capacities. The possible use of genetically engineered micro-organisms for dealing with such problems in the form of major pesticide spills, and waste pesticides and containers is also briefly explored. Whilst the validity of application to waste pesticides and rinsates is clear, the question of control of such bacteria after release into the environment is not addressed.

- E. Evaporation basins, as detoxifiers of pesticides, are effective through photodegradation, chemical hydrolysis, fixation (by adsorption), sedimentation and volatilization. Microbial degradation, whilst usually a factor also, is less significant than in biological systems (as classified in this document) because of conflicting factors (such as low organic matter content and high pH, etc.), which favour other mechanisms of breakdown<sup>129</sup>. Volume reduction occurs through evaporation from basins. Such basins are typically lined with plastic, and whilst commonly used by manufacturers, SCS Engineers<sup>130</sup> believe that there is also application on the farm because of the cheapness and simplicity of the method. Certain precautions would be desirable (e.g., fencing, roofing and erosion control measures), but both concentrated and dilute pesticides could be disposed of in this way. The main disadvantages of this method are the potential for impairment of air quality, the limitations imposed by climate<sup>131</sup>, and the fact that periodical cleaning out would be desirable.
- F. Miscellaneous other disposal methods include dilution, release of the pesticide to the air, or ground surface disposal<sup>132</sup>. Success of disposal onto ground surfaces is dependent principally on photodecomposition, microbial action, and oxidation, for detoxification. The pesticide should be at tankmix concentration (or less), and should be able to spread thinly on a level, slightly elevated surface. Lawless et al<sup>133</sup> suggest that more readily biodegraded pesticides may be diluted and discharged to the sewer, but there are limitations to this method. Gaseous or volatile liquid fumigants known to be degraded in the atmosphere are suited to disposal by release into the air. Volatile liquids may be disposed of by pouring onto sand or porous soil<sup>134</sup>.

At the completion here, of this overview of the more scientific literature on disposal methods, it is worthwhile to consider some general overviews of disposal methods. Lawless et al<sup>135</sup> in 1975 wrote of pesticide concentrates:

Over 25% of the pesticides are so hazardous to man or the environment or the state of knowledge on their degradation is so incomplete, that the recommended disposal procedure is for the layman to place his pesticide in the hands of a professional rather than to attempt to detoxify it himself, i.e., turn it in to a collection centre, return it to a supplier, or transfer it to an industrial waste service. For all but the most toxic of these pesticides, however, alternative disposal procedures have been listed. Another group of approximately 30% of the pesticides are so environmentally persistent, thermally stable, or resistant to chemical degradation, that the preferred disposal procedure is incineration in efficient equipment of a type not normally owned by a layman. Alternate disposal procedures have also been suggested for many pesticides of this group. For the remaining 45% of the pesticides, disposal procedures are recommended which the layman can use himself: chemical detoxification is suitable for 15% of the total and either burning, ground burial, ground-surface disposal, dilution, or release to the air may be employed for 30% of the total. Documented examples of the demonstrated effective and safe use of these procedures for specific pesticide chemicals and pesticide formulations were generally unavailable, however, and a major recommendation is that such studies be conducted.

SCS Engineers present a comparative assessment of the alternatives for disposal of dilute pesticides on the bases of safety, effectiveness, versatility for a range of pesticides, implementation and provenness, and the skill required for operation<sup>136</sup>. Soil mounds were most favoured, and high rating was given to chemical treatment, and removal for incineration. The ratings are summarized in Appendix V, but should be viewed with the knowledge that the volumes of waste being considered are far greater than those normally encountered on a farm.

## II. Disposal Methods for the Farm and Farmer

This section looks closely at the body of information on disposal of waste pesticides which is aimed at the farmer or the farm situation. This information is found in codes, on package labels, in government publications, etc., and represents one end-use of the information given above. In general, the information given below is readily accessible to the farmer.



- A. United States: recommendations made by the Environmental Protection Agency<sup>137</sup> are, firstly, incineration at a state approved facility, or if this is not possible, burial at a local sanitary landfill. Other alternatives suggested are soil injection (incorporation into the plough layer) or chemical degradation. The booklet published by the Environmental Protection Authority<sup>138</sup> does not give detail of chemical disposal method, instead referring the farmer to the Environmental Protection Agency, for advice on this approach. Where none of these alternatives are possible, continued storage under specific conditions is recommended until disposal facilities become available. The pamphlet under discussion is not the only one available to farmers in the United States, but the author was unable to procure others for viewing. It is to be expected, however, that instructions such as those above would form the basis of any others. Methods suggested by Lawless et al<sup>139</sup>, whilst suitable for the layman are not published in a form immediately accessible to the farmer, nor are they all suitable for application by the farmer.

Pesticide container labels are a source of information on disposal techniques in the United States, and a recent review assessed this source<sup>140</sup>. Less than half of the labels examined gave any information at all on disposal, and of those that did, burial was recommended in approximately 89% of (single active ingredient) products. It is curious that this recommendation should differ from that of the Environmental Protection Agency as given above, because the same organization is responsible also for product registration and labelling. Disposal onto landfill was the next most common recommendation (33%), followed by chemical reprocessing (29%), incineration, burning (also at variance with instructions as above), and return to the manufacturer. For combination products (i.e., those containing more than one active ingredient) burial again was the most frequently mentioned technique. In general, the advice on labels included hints on siting of disposal pits, etc.

B. United Kingdom and Europe: the only advice for farmers or for farm situations which the author found, was issued by the Department of the Environment<sup>141</sup> and the Ministry of Agriculture, Fisheries and Food et al<sup>142</sup>, the latter of which is in a small booklet suitable for the farmer. In addition to the usual approaches for minimizing the need for disposal, a list of nearly 200 pesticide active ingredients is given for which disposal onto cereal stubble is recommended. This list is reproduced in Appendix VI, together with some of the instructions for disposal. Notable among the instructions is the restrictive directive that such treated areas should be ploughed and sown with barley the following Spring. No other crop may be sown without consultation with the local official agricultural adviser<sup>143</sup>. For products not on this list, or where stubble application is not possible, a waste disposal contractor or the "local authority" should be consulted. Rodenticides should be buried or burnt. Veterinary or granary pesticides should be diluted to tankmix strength and taking normal precautions, be applied to outside structural surfaces of farm buildings. The Department of the Environment<sup>144</sup> suggests occasional disposal onto impervious surfaces such as concrete, at a rate of 5 litres/hour or 25 litres/day on an area of 2m<sup>2</sup>. Disposal of fumigants should be carried out only after consultation with the local agricultural adviser. Spent sheep dips should be disposed of by use of a soil soakaway near the dip, or alternatively, by spreading the fluid on a nearby area of level soil which offers no possibility of contaminating water courses, livestock, man or crops.

No pesticide labels from the United Kingdom, nor surveys of label wording were seen. Whilst registration requirements relating to labelling do not demand any description of disposal method, vague wording on the 'don'ts' of disposal is suggested<sup>145</sup>.

Suggestions for disposal by the European farmer, put forward by the Council of Europe<sup>146</sup>, are second-rate being based largely on a lay report of a conference<sup>147</sup> and do not bear repetition. No recommendations appear to have been made by GIFAP<sup>148</sup>.

- C. Australia: information on disposal of waste pesticides is provided by such bodies as (State) Departments of Agriculture<sup>149</sup>, the (Federal) Department of Primary Industry<sup>150</sup>, environmental authorities<sup>151</sup>, (Victorian) Department of Crown Lands and Survey<sup>152</sup>, research bodies such as Commonwealth Scientific and Industrial Research Organization<sup>153</sup>, and private industry bodies such as the Agricultural and Veterinary Chemicals Association<sup>154</sup>, and a copy of the latter is shown in Appendix VII. It should be noted also that the Standards Association of Australia has produced a standard relating to storage and disposal, but it is aimed primarily at the manufacturer and distributor rather than the farmer<sup>155</sup>. Detailed instructions on disposal have not been produced by any individual manufacturers<sup>156</sup>. General recommendations from all of these sources are very similar and all have their basis in methods suggested originally by the (Federal) Department of Primary Industry in 1968<sup>157</sup>. Some updating of these original recommendations has taken place.

According to these instructions, the disposal site for pesticides and containers should have no other use, should be separated from crops, livestock, water and homes by some distance, and fencing around the site is desirable. The disposal area should be flat in order to minimize the chance of pesticide-containing runoff reaching streams, etc. Sites to be avoided are watersheds, deep pits, creek beds, erosion gullies, quarries, 'sinks' and holes that extend into the water table. Some variation in the recommended soil type for the disposal site was seen, but the original instructions were aimed at ensuring rapid dissipation of the liquid being disposed of.

The actual recommended method of disposal is simple: firstly, the farmer is advised to find another who would use the waste; or secondly, if that is not possible, return unopened containers to the supplier. Where these methods are inappropriate, the pesticide should be diluted to tankmix concentration and poured into a hole at least 50 cm deep, the bottom of which is lined with lime. After dispersal of the liquid, the hole should be covered with soil. Waste pesticides already at tankmix concentration or spent sheep or cattle dip should be disposed of in the same way, whilst pesticides in powder-form should be buried dry. Rinsate from containers, equipment, etc., should be spread onto the ground, which ideally should be cultivated to accelerate absorption and degradation. Waste pesticide should not be burnt.

Specific comment is required on a method of disposal of sheep dip designed in Tasmania by Gillham<sup>158</sup>. Designed in response to a request from farmers, the pit has not been tested, but co-incidentally, its design is not unlike that of micropits tested at the University of Iowa<sup>159</sup>. A copy of the original publication by Gillham is given in Appendix VIII.

Pesticide labels in Australia are a poor source of information on methods of disposal. A crude survey of Australian pesticide labels from 14 manufacturers, described in detail in Appendix IX, revealed that no labels included instruction on the disposal of waste pesticide, although some comment was found on what *not* to do. There is no legal requirement in any State to display on the label instructions on how to dispose of surplus or waste pesticides<sup>160</sup>.

- D. Summary: clearly, the approach to disposal in different parts of the world varies. In the United States, a centralized form of disposal is advocated ahead of other methods, and this may reflect a general desire to control these wastes as closely as possible using methods of known efficacy which produce largely known by-products. This approach also

represents a means of reducing the release of pesticides into the general environment. Whilst recommendations made in the United Kingdom have a scientifically valid basis, they do require some specific effort from the farmer, and may also mean some disruption to use of parts of the farm. Recommendations in Australia seem to give practical recognition of the larger size of property (than, for example, in Europe) with its greater availability of spare land, the generally lower rate of pesticide use (than, for example, in the United States); and the lower density of human settlement (than, for example, either Europe or the United States). There are however, points of interest in the local recommendations.

Firstly, the recommendation to dispose of pesticides into sandy, permeable soil appears to ignore the desirable features (for disposal) of heavier soils. The clay and organic matter content of heavier soils are always or almost always greater than in sandy or light soils. Chapter 2 described the importance of clay and organic matter as agents which immobilize pesticides in the soil, and immobilization is a desirable feature of pesticide disposal. Furthermore, the greater ability of the heavier soil to retain water and nutrients is almost a guarantee of greater microbial activity in such soils - a further agent important in degradation of pesticides in soils. For scientific reasons then, and if recommendations from other countries have any validity in Australia, there is reason to believe that recommendations for Australia may not be ideal. However, the thinking behind Australian recommendations also has validity: the pesticide liquid should disperse quickly, the amounts being disposed of are generally small, and in general, aquifers in Australia tend to be lower (than, for example, in the United States<sup>161</sup>). Against these points is the generalization that is made about quantities being disposed, and the fact that certain areas (for example, the Huon Valley in Tasmania<sup>162</sup>) have high and plentiful underground watercourses.

Secondly, the recommendation for inclusion of an alkaline substance, lime, in a disposal pit also differs from recommendations made elsewhere. Whilst the main purpose of the lime is to accelerate breakdown of the generally alkali-labile organophosphorus compounds, the work of Shih and Dal Porto<sup>163</sup> and Lande<sup>164</sup> suggested that decomposition by alkaline hydrolysis of a number of pesticides, including some organophosphorus compounds, is inappropriate<sup>165</sup>. Furthermore, the combined toxic effects of pesticide and high alkalinity from the lime are unlikely generally to enhance microbial activity in the immediate vicinity of the waste pesticide deposit, and the question is raised, whether degradation of acid-labile pesticides is hindered<sup>166</sup>. Finally, the recommendation for use of lime was made around 1970, a time when organophosphorus compounds were more in vogue than now<sup>167</sup>. On the other hand, organophosphorus compounds remain among the most toxic. Also, Lawless et al<sup>168</sup> found that alkaline hydrolysis was the most suitable method of disposal for 60 pesticides (of a total of 550 assessed). Moreover, it was recommended that the degradation be carried out in a soil pit.

Thirdly, the question of the appropriate depth of a pit on the farm requires brief comment. Local instructions suggest a depth of at least \* 50 cm, implying that the minimum depth should be 50 cm, but the deeper the better. Moore<sup>169</sup> draws attention to the basic ecological fact, that greater depth of burial means decreased temperature and oxygen concentration around the deposit, and a consequent reduction of microbial activity. Additionally, greater depth means increased proximity to any water table. However, in many soils, clay content increases with depth, and as a result, also the immobilizing capacity for some pesticides. It must be recognized, however, that ultimately the most important determinant of the success of disposal is chemical change of the active ingredient, not merely immobilization.. Microbial action is generally the most important agent of chemical change in the soil.

\* Author's italics.

These comments which conclude this section highlight again the many variables involved in disposal of pesticides, and the difficulty of finding methods or a method, appropriate to most situations.

### 3.3.2 Pesticide containers

Disposal of pesticide containers has not been the subject of research as detailed or as extensive as for pesticides, although it should be pointed out that container disposal is a problem confronting the farmer far more frequently than pesticide disposal. Of the five major reviews of pesticide disposal mentioned above<sup>170</sup>, Lawless et al<sup>171</sup> and Münnecke<sup>172</sup> give basic coverage to methods of rinsing and disposing, Lange<sup>173</sup> reviews results of recent experiments on rinsing, and Little et al<sup>174</sup> gives major emphasis to the physical disposal of the actual containers.

Scientific investigation of container rinsing has been carried out by Staton et al<sup>175</sup>, Archer<sup>176</sup> and Archer and Hsieh<sup>177</sup> using a variety of solvents, including water, caustic soda, ethanol, ethanol-acid, benzene, isopropanol and acetonitrile. The best results were obtained using water followed by caustic solution, ethanol, or ethanol-acid. Recommendations for disposal by incineration seem based only on studies of free pesticide incineration.

Recommendations to the farmer are basically similar in different countries examined, and the two aspects of disposal, decontamination and actual disposal are discussed below:

- A. Decontamination is generally recommended only for non-combustible containers in the United States, where the recommended procedure appears to have devolved over a number of years to a relatively simple process. Earlier recommendations for the farm situation involved use of detergent and lye<sup>178</sup> or perhaps oxidising or reducing agents, or acids or alkalis<sup>179</sup>, but it seems unlikely that such methods were aimed specifically at the farmer.

Current recommendations of the Environmental Protection Agency and the National Agricultural Chemicals Association are a three-stage decontamination<sup>180</sup>: (i) empty the container into the tankmix container and drain for 30 seconds; (ii) rinse the

container at least three times using a volume of water at least 10% of the container's total volume; and (iii) add rinsate to the tankmix and dispose of the container. The instructions include normal precautions of clothing, etc., and some emphasis is given to the fact that rinsing is a preparation for disposal, not for re-use of containers. The work which is the basis of this three-stage process is unknown, but von Rümke et al<sup>181</sup> suggested that no amount of cleaning and decontamination on the farm would make a container suitable for re-use. The use of detergents, lye, etc., seems pointless therefore. Brambley et al<sup>182</sup> make no mention of rinsing instructions found on container labels in the United States.

The methods suggested in the United Kingdom for container decontamination have been promulgated by the Department of the Environment<sup>183</sup>, the Ministry for Agriculture, Fisheries and Food et al<sup>184</sup>, and the British Crop Protection Council<sup>185</sup>. Only those from the Ministry are farmer oriented, and they recommend thorough emptying, triple rinsing with water of the closed container with a quarter the full container volume, and disposal into the tankmix for application. General safety precautions also are mentioned. Recommendations by the Council of Europe<sup>186</sup> are the same in principle, but represent a minimum. No suggested routine by GIFAP is known.

In Australia, recommendations have come from the same sources as for pesticide disposal<sup>187</sup>. The decontamination instructions are less rigorous than recommended in either the United States or United Kingdom, and rinsate should go into the tankmix or to a suitable disposal site. In general, normal safety precautions are not as strongly stressed. There is no legal requirement for appearance on the label of information relating to decontamination<sup>188</sup>.

- B. Disposal of containers is a little more complex depending on whether or not a container is combustible. In the United States, the recommendations of the Environmental Protection Agency<sup>189</sup> and the National Agricultural Chemical Association<sup>190</sup> for the farm situation, is that combustible containers should be burnt in an open fire at



the site of use, if permitted. Alternatives are burning at a public dump or in a commercial incinerator, or treating it as non-combustible, as below. Containers which have held herbicides, particularly hormonal sprays (such as 2,4-D or 2,4,5-T) or metal-containing compounds (such as mercurials, arsenicals, etc.) should not be burned because of the vapours emitted which may adversely affect plants some distance downwind. Non-combustible containers, containers which have held herbicides, and according to at least one author<sup>191</sup>, containers which have held organophosphorus compounds, should all be buried. Burial should be preceded by removal of caps or bungs, and puncturing and crushing of metal containers or smashing of glass containers. Recycling of larger containers (e.g., 20 and 55 gallons) is another suggested method of disposal. Pressurised containers should be buried without puncturing<sup>192</sup>. Brambley et al<sup>193</sup> state that the most common recommendation on labels is burying, and next most common, burning.

Recommendations in the United Kingdom differ very little from those in the United States, and the same special cases are singled out. Because of the risks of explosion or of the generation of phytotoxic vapours, the Ministry of Agriculture, Fisheries and Food has compiled a list of active ingredients, the containers of which should not be burnt<sup>194</sup>:

benazolin	dichlorprop	picloram
2,4-D	fenoprop	sodium chlorate
2,4-DB	MCPA	2,4,5-T
dicamba	MCPB	2,3,6-TBA
3,6 dichloropicolinic acid	mecoprop	
Others marked as highly inflammable, pesticide smoke preparations, and atomizable fluids.		

Table 7: Contents of pesticides in containers not allowed to be burnt.

In general, the instructions issued in the United Kingdom are more detailed for burial and burning sites, and the method of burning is described<sup>195</sup>. Registration requires mention on labels on disposal of rinsate from containers, and on how the container should be disposed of<sup>196</sup>. Council of Europe recommendations<sup>197</sup> add nothing to British instructions.

The first recommendation made in Australia is for disposal by recycling to the supplier, or transport to the local tip. Disposal by burying on the farm is the least common recommendation. Instructions on crushing and holing, and removal of caps and bungs appear among all recommendations, but discouragement from re-use is not universal. Advice on site selection is commonly found, but outside of Australia, specific recommendations for sandy soil<sup>198</sup> were seen only among the recommendations of the National Agricultural Chemical Association<sup>199</sup>.

Most Australian labels surveyed suggested rinsing of containers, but only a small number suggested burning, crushing or burying. Where disposal of the container was mentioned, wording was vague and served only as a reminder that the task should be performed. Greater detail of label contents appears in Appendix IX. Again, no legal requirement for label instructions exists<sup>200</sup>.

### 3.3 METHOD OF PESTICIDE STORAGE

Because the art of safe pesticide storage is largely a matter of common-sense application of well established safety principles, there has scarcely been a need for any methodological research.

Guidelines for the farmer appearing in the booklet published by the Environmental Protection Agency in the United States<sup>201</sup> advocate attention to: (i) siting, which should be away from areas prone to flooding, and close to adequate and suitable drainage; (ii) structure of the sheds housing the pesticides, which ensures dryness, ventilation, easy access, separation of pesticides from other goods, and fireproofness. Storage areas should also be clearly marked as such and suitable security devices should be applied; and (iii) records of movements which should be kept up-to-date.

Brambley et al<sup>202</sup> report that the six most common statements on pesticide labels in the United States relate to removal of the containers from heat, fire and sparks, separation of containers from seeds, feeds and foodstuffs, separation from seeds, feeds, fertilizers, insecticides and fungicides, storing at temperatures above 32°F, storing under cool and dry conditions, and storing under dry conditions. Further label recommendations include storage only in original containers, separation of herbicides from other pesticides, storage in a ventilated area, and separation of pesticides from toys, dishes, cosmetics, clothing and furniture.

Recommendations in the United Kingdom made by the Ministry of Agriculture, Fisheries and Food, include storage in dry, well ventilated and secure areas, and such areas should be away from food and feedstuffs<sup>203</sup>. Old stock should be used first, and all movements should be recorded. Label wording is required to make mention of separation from food, feedstuffs, and drink, storage only in the original container, tight closure of the container, and storage in a secure or locked area<sup>204</sup>. Guidelines from the Council of Europe<sup>205</sup> for the farm situation make reference to:

- (i) security in a building located far from domestic property; (ii) location on land not subject to flooding and away from water courses and open drains; (iii) construction of the storage from non-combustible material; (iv) good ventilation and illumination, prevention of frost and security from animals; (v) separation of the different types of pesticide (i.e., herbicide, fungicide, etc.), and of the pesticides from animal feedstuffs; and (vi) record keeping of pesticide movements, and first use of older pesticide.

In Australia, recommendations on the correct storage of pesticides have been issued by the Standards Association of Australia<sup>206</sup>, the (Federal) Department of Primary Industry<sup>207</sup>, the Agricultural and Veterinary Chemicals Association<sup>208</sup>, and the Commonwealth Scientific and Industrial Research Organization<sup>209</sup>. Those issued by the Agricultural and Veterinary Chemicals Association have the greatest orientation towards farmer needs, and may be seen in full in Appendix X. The main points made are: (i) storage should be in a separate locked building away from children and animals. The structure should ensure cool, dry, well ventilated storage in conditions of low humidity and free of water leaks; (ii) all containers should be

kept sealed; (iii) no unlabelled, leaking, or food containers should be used for storage; and (iv) herbicides should be stored away from other pesticides, preferably in another room.

The survey of Australian labels, reported in greater detail in Appendix IX, revealed that 71% of labels examined bore some comment on storage method. However, these instructions often fell far short of those enumerated above.

### 3.4 EFFECTIVENESS AND EFFECTS OF PESTICIDE AND CONTAINER DISPOSAL

In Chapter 2, a general overview was given of the negative effects which arise from distribution of pesticides in the natural environment, and at the beginning of this chapter, the hazards of failure to dispose of pesticides and containers were described. It has been shown that a number of methods of pesticide disposal exist, and also that there is a great number of different pesticide active ingredients in use. Depending on the particular combination of disposal method employed, and pesticide subjected to this particular treatment, the outcome will be one of two possibilities: firstly, the pesticide may be relatively quickly and completely detoxified, or secondly, it may be relatively slowly or never detoxified. These comments apply equally to waste pesticides and to container residues. This chapter considers the possible results of the 'second best' of these two outcomes, and emphasizes at the outset, that most of the disposal methods described earlier in this chapter fall into this category. In other words, active pesticide is released into the environment as part of a disposal technique, and the resultant contamination of soil, water and air has the potential to cause damage.

A number of accidents, attributable directly to disposal of pesticides and containers, are cited by Little et al<sup>210</sup>. These include fishkills (sic), poisoning of farm animals, contamination of creeks, groundwater and domestic water, as well as more general kills of aquatic organisms. Little et al<sup>211</sup> believe that the number of such instances which are recorded represent only a small proportion of all such mishaps. It should be noted here that the difference between mishaps arising from failure to dispose of wastes, and from inadequate disposal, is small and not important; whilst the circumstances may differ, the end result is largely similar.

Disposal by combustion on the farm and by industrial means is discussed above. According to Little et al<sup>212</sup>, the impact on the environment which arises from farm burning is a result of incomplete combustion of the active ingredient. Products of burning on the farm of pesticides and containers include intermediate compounds<sup>213</sup> and unchanged chemical as well as completely combusted material. These compounds may represent a hazard to humans, domestic animals, wildlife, etc., downwind, because some combustion products remain toxic at exposure levels of few parts per million. Little et al<sup>214</sup> pointed out that for every ten 'source diameters' movement away from the source, an approximate twenty-fold dilution of vapours, etc., occurs, but they still recommend a clearance of several hundred feet downwind to the nearest humans, livestock, etc. These comments apply equally to pesticides and containers, and Wolfe et al<sup>215</sup> stated that the burning of containers on the farm can produce levels of active ingredient in the air appreciably greater than those resulting from normal application. However, in general, the duration of exposure to the products of burning would be considerably less than to pesticide spray. In addition to air-borne hazards, there are potential dangers arising from explosive pesticides such as sodium chlorate, and problems arise from the release of highly active vapours from such volatile compounds as 2,4-D. Little et al<sup>216</sup> consider that repeated burning on one site may lead to development of high concentrations in a small area of residues which are toxic to livestock and other species, and which are subject to mobilization by water.

Industrial incinerators, in theory and often in practice, can be operated with a minimum of discharge of toxic products, and this method of disposal, because of its cleanness as well as its predictability, is frequently regarded as the best disposal method of all. 'Dirty' incinerators may release gases such as carbon monoxide, nitrogen oxides, sulphur dioxide, elemental halogens and hydrogen halides, as well as solids such as smoke, particulates and ashes containing alkalis, and alkaline earth and heavy metals. Incompletely combusting incinerators may produce gases such as hydrogen sulphide, ammonia, hydrogen cyanide, and incompletely destroyed pesticides<sup>217</sup>. Greater detail of information on the exhaust products of pesticide combustion may be found in the predictions made by Tabor<sup>218</sup>, and Kennedy et al<sup>219</sup> list in some detail the decomposition products of 20 assorted pesticides. Wilkinson et al<sup>220</sup> note that the uncontrolled

release of such products poses a serious threat to the quality of air, water and soil, as well as plant and animal life near the incinerator. However, these comments relate to disposal operations far greater than normally found on a farm. When unfavourable meteorological conditions, such as low wind velocity, rain, or thermal inversions coincide with times of incineration, environmental damage can be accentuated. In particular, low concentrations of sulphur dioxide, nitrogen dioxides, fluorides, chlorides, aliphatic hydrocarbons and some unchanged herbicides such as 2,4-D, can cause acute damage to plants. Loss of plant life can lead to profound changes in soil, and perhaps ultimately to erosion with its attendant problems. Pollution of water from such incineration is possible, and water may be rendered unsuitable for agricultural, recreational or domestic use, as well as having a generally deleterious effect on aquatic life. Finally, the hazards associated with handling and transport of wastes to a central location must be considered.

Chemical disposal, as advocated by Shih and Dal Porto<sup>221</sup>, Lande<sup>222</sup> and Lawless et al<sup>223</sup> presents potential hazards because of the need to handle such chemicals as acids, alkalis and oxidisers as well as the pesticides themselves. All of these authors advocate observance of normal safety precautions whilst executing disposal by chemical means, and soil pits are the preferred site of final disposal. Chemical reactions of the types suggested are not normally instantaneous nor are they usually wholly effective. Therefore, there will generally be either some unchanged pesticide or some detoxifying agent remaining from these procedures, and the potential effects of these in the environment have already been described. It should also be emphasized that knowledge of the products of hydrolytic detoxification is incomplete<sup>224</sup>, and for this reason only qualified acceptance of the recommendations of Lawless et al<sup>225</sup> and of the universal recommendation in Australia for the lining of disposal pits with lime<sup>226</sup>, is possible.

Decontamination of pesticide containers by chemical means, even at commercial plants, leaves residues in the containers. Techniques described above<sup>227</sup> are more refined than those used by farmers, and in all cases removal of pesticide residues from containers of between five and 200 litres' volume, was incomplete. After drainage, the amount of residue removed was generally between 90% and 99%; but lower efficiency

of removal was observed. Depending on the active ingredient, dilution with water of after-use residues in the container up to full container volume may result in a solution which represents a significant hazard to mammals. Decontamination on the farm, therefore, with or without chemicals, leaves a container still holding potentially hazardous residues, and additionally, the rinsing procedure generates dilute pesticide. These potential hazards are discussed further below.

Environmental hazards associated with disposal by biological means, and particularly with disposal into soil, appear to have received more attention than hazards associated with other methods. One possible reason for this is that biological means of disposal often involve release of the unchanged pesticide into the environment. The hazards associated with disposal into pits or dumps (open or buried) and onto pasture or stubbles are readily apparent, and they depend largely on the solubility, mobility, persistence and toxicity in the soil of the pesticide<sup>228</sup>. Both surface and groundwater may be contaminated by leaching, particularly streams and shallow aquifers<sup>229</sup>, and some work done on this problem in Australia is reported in Chapter 4<sup>230</sup>. Surface water contamination may lead to such unwanted results as acute toxic effects in stream flora and fauna, or to accumulation of pesticides in groundwater. (Contamination of groundwater is in general a bad thing, but in the United States, for example, where 20% of total water needs are met by groundwater, it is particularly serious.) Contamination of soil will generally cause changes in soil microbial populations, and may lead to increased numbers of pathogens or pesticide-resistant microbial strains, and decreased numbers of beneficial species. The study by Stojanovic et al<sup>231</sup> is one of very few on the effects of pesticides at high concentrations in soil. From a selection of 20 pesticides (13 herbicides, four insecticides, two fungicides and one nematicide), only one preparation raised soil bacteria populations. Eleven of the products favoured growth of *Streptomyces* spp., and nine depressed fungal populations. Stojanovic et al<sup>232</sup> postulated that general shifts of microbial populations occur, and certain groups will dominate. If bacteria are depressed over an appreciable period, important bacterial processes such as nitrification, nitrogen fixation, sulphur transformations, etc., will be jeopardized, although generally, only a small area would be affected. In the only other study known to the

author, of pesticides at high concentration in the soil, Davidson et al<sup>233</sup> found that increasing pesticide concentration was related to higher pesticide mobility and decreased degradation rates. Total microbial activity decreased at higher soil pesticide concentration, but the populations of bacteria, fungi and actinomycetes<sup>234</sup> in this study responded differently to those described by Stojanovic<sup>235</sup> perhaps for reasons of differing clay and organic matter content of the soil in each case.

Little et al<sup>236</sup> claim also that soil fauna, such as worms, mites, etc., which are also important in biochemical cycles, are adversely influenced by disposed waste pesticides. Further, it is possible that such species may be early members of a pesticide food chain.

A slight extension of claims made by Wilkinson et al<sup>237</sup> would indicate that pesticide disposal could mean a boon for manufacturers of all types of agricultural chemicals. Not only is disposal one type of pesticide consumption, but also it is suggested that disposal of pesticides may so affect microbial populations, and with them nutrient cycles, that application of additional artificial fertilizers may become necessary. Furthermore, it is possible that populations of pest predators<sup>238</sup> may be so depressed, that greater use of pesticides may be necessitated.

Disposal of pesticides into the soil may be followed by volatilization into the air of unchanged pesticide, or of the products of photolysis, microbial degradation, etc., particularly in the cases of unstable pesticides. Deposits of stable pesticides in soil could also continue to be sources of air pollution for many years, unless buried in impervious containers<sup>239</sup>.

The problem of recalcitrant residues in containers has been already described. Disposal of containers, therefore, represents a hazard to many species particularly where containers are unrinsed or are openly dumped. Species at risk include native fauna, livestock and other domestic animals, and exposure may be facilitated by the filling and dispersing actions of rain.



In summary, the hazards posed by burial of pesticides and containers vary considerably according to the care and expertise of the disposer, and in the United States, management of public disposal sites receives much attention<sup>240</sup>. For disposal of pesticides or containers in an open pit, or even 'under the nearest bush', any or all of the simple expedients of dilution or rinsing, crushing, puncturing or smashing, covering and perhaps packing with soil, liming of the pit (?) and careful site selection can greatly reduce any hazards. At worst, humans may be affected by direct contact with inadequately disposed pesticides or containers, and at best a small and insignificant amount of damage occurs in a small area.

Disposal by land cultivation is claimed to put birds and animals at risk, and reliability of the method and mobility of the pesticides disposed in this way are areas of meagre knowledge<sup>241</sup>. Soil pits of the man-made variety may be a source of air pollution, but both pits and mounds virtually eliminate any chance of direct contact with anything other than soil-dwelling organisms, and then only those inside the pit or mound.

In general, evaporation basins are no threat to water quality because the pesticide-sludge liquid is effectively contained. However, air pollution by pesticides and their by-products, and by odour is a possible outcome of their use.

The discussion above outlines a range of negative consequences arising from disposal of pesticides and their containers. Whilst highly undesirable effects of disposal can and do occur, their extent is usually minor, and their severity, mild.

### 3.5 COSTS OF PESTICIDE AND CONTAINER DISPOSAL

The social and environmental costs resulting from the use of pesticides were discussed briefly in Chapter 2, and a certain small proportion of these costs would be attributable to the effects of pesticide and pesticide container disposal. What follows in this section is a consideration of the direct costs of disposal.

### 3.5.1 Pesticide container disposal

Costs of disposing of pesticide containers are considered by Jansen<sup>242</sup> and Little et al<sup>243</sup>. Because of the different approach used by each, it is difficult to compare directly their differing estimates, but the difference seems small. Jansen<sup>244</sup> estimated the cost of burying on the farm four 5 gallon drums, or two 55 gallon drums or ten small containers to have been approximately US\$2.30 in 1970. Little et al<sup>245</sup> estimated the costs at approximately US\$0.55 per single 5 gallon drum for on-farm burial in 1977. According to Jansen<sup>246</sup>, total costs of labour and mechanical aids for farm burial in 1964 would have been approximately US\$31 million, around 15% of the sales value of all pesticides used.

The calculations of Little et al<sup>247</sup> are somewhat more detailed than those of Jansen<sup>248</sup>, for he considers also the costs of intermediate handling and/or storage, the costs of disposal away from the farm, as well as possible variations. The estimated costs of storage at an intermediate holding area are relatively low, and of final disposal at a landfill dump, about US\$0.027 per 5 gallon container. Transport costs additional to these are subject to a number of variables, and are quite significant. In such a system as that depicted by Little et al<sup>249</sup>, where ultimate disposal at a central point is possible, the optimum arrangement depends on the rate of container generation and the distribution of sources. However, the costs of on-farm controlled burial when compared with disposal at a regionally developed system, were found to be approximately half as much as the latter.

### 3.5.2 Pesticide disposal

Pesticide disposal, as on on-farm activity has received less study than pesticide container disposal. SCS Engineers, using certain assumptions, have calculated the relative costs per volume of disposal of dilute pesticides as on next page<sup>250</sup>:

Disposal Method	Relative Cost (per unit volume)
Evaporation basin	1.00
Soil pits	1.13
Soil mounds	1.14
Land cultivation	1.32
Incineration	12.59

Table 8: Relative costs of different methods of dilute pesticide disposal.

If a centralized system(s) of disposal were adopted in Tasmania, the costs<sup>251</sup> and relativities shown in the table would remain reasonably true. However, as mentioned earlier in this chapter, the SCS Engineers' assessment was based on a feed rate of 1,700 litres per day of operation for 225 operating days per year - a quantity which exceeds by far the generation rate of any normal farm. It is therefore questionable that these costs have much relevance to the farm situation. Wilkinson et al<sup>252</sup> considered the potential economic impact of a variety of disposal methods, but because all are on a scale completely inapplicable to the farm and probably for Tasmania as a whole, any review of these data is pointless. Münnecke<sup>253</sup> claimed landfill to be the cheapest disposal method at approximately US\$2 - 13 per tonne; all other methods mentioned are more suited to industrial situations, and are also more expensive. Disposal of wastes from pesticide manufacturing is approximately 0.9% of the product sales price according to Münnecke - somewhat less than the 15% claimed by Jansen<sup>254</sup> for container disposal. Ghassemi et al<sup>255</sup> did not present data on disposal costs per unit of weight or volume, but information on capital and operating costs for a series of public landfill disposal sites in the United States was given. Despite the size and title of their publication, Little et al<sup>256</sup> gave no estimates of costs of pesticide disposal.

### 3.6 LEGAL ASPECTS OF DISPOSAL

In this section, consideration is given to what legislation exists in relation to the act of disposal, and what information is required of the product registrant before registration is granted. The requirements for product labels have already been discussed in section 3.2.1 II of this chapter.

#### 3.6.1 United States

Regulation of pesticide registration, labelling and use is governed in the United States by the Federal Insecticide, Fungicide and Rodenticide Act, 1972, and is administered by the Office of Pesticide Programmes of the Environmental Protection Agency. In a general sense, the provisions of this Act are aimed at

*..... protection against any unreasonable  
adverse effects on the environment<sup>257</sup>.*

Under Section 19 of the Act, the Environmental Protection Agency is directed to

*..... establish procedures and regulations  
for the disposal or storage of packages and  
containers of pesticides, and for disposal  
or storage of excess amounts of such pest-  
icides and accept at convenient locations  
for safe disposal a pesticide, the registr-  
ation of which is cancelled ..... if  
requested by the owner.*

Furthermore,

*..... notification of cancellation of any  
pesticide shall include specific provisions  
for the disposal of the unused quantity of  
such pesticides.*

The procedures, regulations, etc., proclaimed in May 1974<sup>258</sup> and subsequent regulations find their basis in the hazards of disposal and storage, as documented in such reports as 'Report to Congress: Disposal of hazardous wastes'<sup>259</sup>. These laws describe in some detail how the farmer should go about storage and disposal of pesticides and containers. Additionally, there are specific prohibitions on open dumping, open burning, water dumping, well injection, and contamination of food and feed supplies.

Product registration requires the registrant to provide data on the recommended methods of pesticide and container disposal<sup>260</sup>, although this information may not be relevant to the farm situation. It is of note that there is currently a programme in the Environmental Protection Agency under consideration, which is aimed at generating more or better information on disposal methods for inclusion in package labels<sup>261</sup>.

### 3.6.2 United Kingdom

The specificity seen in the United States law is not a feature of either the British or Australian law relating to matters of disposal. In Britain, the disposal of pesticides by the farmer is governed by three Acts<sup>262</sup> which relate (among other things) to prohibition of the deposition of noxious substances on land in a way which creates a hazard to persons or animals, and to the protection of people directly involved in disposal practices. In the context of pesticide registration, the registrant is expected to provide data on the methods of pesticide and container disposal<sup>263</sup>. Nothing is known of registration requirements in other European countries.

### 3.6.3 Australia

The law governing pesticides in Australia is relatively complex. Each State has its own legislation, and a list of the 27 Acts relevant in some way to pesticides is given in Appendix XI. Since 1969, the Technical Committee on Agricultural Chemicals<sup>264</sup> has co-ordinated the registration of pesticides throughout Australia. This committee has only de facto legal standing, which is conferred upon it by the registration authority in each State, such that registration of a product is not granted in any State until the Technical Committee on Agricultural Chemicals is satisfied with validity and content of the data submitted by the registrant<sup>265</sup>. Part of the registration requirement is the submission by the registrant of information on suitable techniques for disposal of both dilute and concentrated pesticides, as well as containers. As already observed, this information is not generally transmitted to the farmer on the label.

The law in Australia relating to pesticide disposal on the farm is virtually non-existent as far as could be determined. In New South Wales, the Pesticide Act, 1978, refers briefly and vaguely to disposal:

*..... a person shall not ..... dispose of a pesticide otherwise than as required or authorized by this Act<sup>266</sup>.*

Further, in cases of cancellation of a pesticide's registration, notification of the cancellation will be made in newspapers, together with

*..... instructions for disposal of the pesticide that have been approved by the Minister<sup>267</sup>.*

In neither case is the approved method described, or further reference to sources of information given. However, in a booklet designed for the farmer which outlines the main points of the Pesticides Act, reference is made to the chart produced by the Agricultural and Veterinary Chemicals Association which described the method.

In Tasmania, legislation relating to disposal of pesticides and containers is found under both the Pesticides, 1968, and Environment Protection, 1973, Acts, which are administered by the Departments of Health, and the Environment respectively. Pesticide Regulations, 1969, under the Act state that a person responsible for disposal of a pesticide

*..... shall ensure that ..... disposal is not carried out in such a manner as to give rise to the contamination of the waters of a lake, pond, dam or watercourse to such an extent or in such a manner that those waters become injurious to any human beings or animals resorting thereto, or the animal or plant life therein<sup>268</sup>.*

Reference is made also, in the Regulations, to disposal of sheep and cattle dips:

*Do not discharge waste liquid into streams<sup>269</sup>.*

Brief reference in the Tasmanian legislation is made also to storage of pesticides. These laws are enforced through the aid of Pesticide Officers in the Department of Agriculture: part of their commission, in this context, is to "observe and report"<sup>270</sup>. In common with much law relating to pesticide disposal, the Tasmanian Pesticide Act describes only what should not be done and these notions are restated in the Environment Protection Act:

..... an occupier of land shall not cause or permit the emission therefrom of a pollutant -

- a. into the atmosphere;
- b. into the sea or any arm or creek thereof, any river, rivulet or other watercourse, or any lake, pond, marsh, or swamp; or
- c. onto or into any other land<sup>271</sup>;

and also, that -

..... no person on land shall

- a. conduct any industry, trade, or process, or any operation for disposing of any industrial, commercial or agricultural, domestic, or other waste .....<sup>272</sup>;

and, also -

..... an occupier of land who causes or permits a pollutant to enter underground water shall be deemed to have emitted it from his land into other land<sup>273</sup>.

In another Section -

A person shall not cause or knowingly permit to flow, put, or knowingly permit to be put, any pollutant into

- a. the sea or any arm or creek of the sea;
- b. a source of supply for a water district, or irrigation water district;
- c. a fishery of the State; or
- d. any river, stream, watercourse, lake, pond, or marsh<sup>274</sup>.

and, in an amendment -

*No person shall dispose of or cause or knowingly permit to be deposited at any place any environmentally dangerous waste except in accordance with a method approved by the Director<sup>275</sup>.*

This last point relates both to disposal on the farm and on municipal tips.

Neither Queensland<sup>276</sup> nor Victoria<sup>277</sup> has any legislation relating directly to disposal of pesticides on the farm. The situations in South and Western Australia, whilst unknown<sup>278</sup>, are probably little different.

In the next chapter, many of the issues raised in this chapter are assessed and discussed in the context of the Tasmanian situation.



NOTES

1. The Australian Science Index, which is a summation of all scientific literature published in Australia, held only two references on pesticide disposal in literature from the last ten years.
2. DEPARTMENT OF THE ENVIRONMENT, 1980; Waste management paper no. 21: Pesticide wastes, p.12; Her Majesty's Stationery Office, London, U.K.
3. HUSSEY, D., Ministry of Agriculture, Fisheries and Food, Harpenden Laboratories, U.K., 1980; Personal communication. Information received covered eleven of the fifteen year span mentioned. Sample size was between 123 and 400 for a total of approximately 150,000 to 200,000 holdings.
4. RILEY, B. T., 1975; Summation of conditions and investigations for the complete combustion of organic pesticides, p.3, EPA-600/2-75-044; Municipal Environmental Research Laboratory, Office of Research and Development, Environment Protection Agency, Cincinnati, Ohio, U.S.A.
5. Tankmix will refer, for the remainder of this document, to pesticide that has been diluted according to manufacturer's recommendations for application to crop, animal, etc. This term does *not* refer to pesticide concentrates purchased as emulsions, powders, granules, etc., from the distributor.
6. DAY, H., 1976; Disposal of dilute pesticide solutions, EPA/530/SW-519, PB 261 160; Environment Protection Agency, Washington D.C., U.S.A.
7. MARSH, J. R., H. PHUNG and D. E. ROSS, 1980; Disposal of dilute pesticide solutions, in: Control of hazardous material spills, Proceedings of National Conference, 1980, pp.403-410; Vanderbilt University, Nashville, Tennessee, U.S.A.
8. MÜNNECKE, D. M., 1979; Chemical, physical and biological methods for disposal and detoxication of pesticides, Residue Reviews 70, 1-26.

9. In view of the relatively extensive volume of literature from the U.S.A. about disposal of pesticides, it seems unlikely that this information does not exist. Such information may, however, exist only on a State basis.
10. AUSTRALIAN ENVIRONMENT COUNCIL, and CONFEDERATION OF AUSTRALIAN INDUSTRY, 1981; Management and disposal of hazardous industrial wastes; Maunsell and Partners, Pty. Ltd., Canberra, Australia.
11. ANON., 1981; Disposal of intractable wastes in Victoria - a draft strategy. Environment Protection Authority, Melbourne, Australia.
12.
  - a. MATTHEWS, D. C., Department of Agriculture, Victoria, 1982; Personal communication.
  - b. The author's own knowledge of the Australian agrochemical industry suggests that these quantities are less than the actual quantities.
13. ROYAL COMMISSION ON ENVIRONMENTAL POLLUTION, 1979; Seventh report: Agriculture and pollution; Her Majesty's Stationery Office, London, U.K.
14.
  - a. JANSEN, L. L., 1970; Estimates of containers numbers by size, type, and formulations involved, in: Working Group on Pesticides, Proceedings of the National Working Conference on Pesticide Disposal, held in the National Agricultural Library, Beltsville, Maryland, in 1970, p.27, PB 197 145; National Technical Information Service, Virginia, U.S.A.
  - b. DAVIS, V. W., 1970; Farmers' use of pesticides and pesticide containers, in: Working Group on Pesticides, Proceedings of the National Working Conference on Pesticide Disposal, held in the National Agricultural Library, Beltsville, Maryland, in 1970, p.39, PB 197 145; National Technical Information Service, Virginia, U.S.A.
  - c. ROPER, W. E., 1972; Pesticide containers and disposal systems, in: Safety Panel of the Federal Working Group on Pest Management, Proceedings of the National Conference on Pesticide Containers, held in New Orleans, Louisiana, in November 1970, pp.185-190; Federal Working Group on Pest Management, U.S.A.

15. FOX, A. and H. DELVO, 1972; Pesticide containers associated with crop protection, in: Safety Panel of the Federal Working Group on Pest Management, Proceedings of the National Conference on Pesticide Containers, held in New Orleans, Louisiana, in November 1970, pp.49-62; Federal Working Group on Pest Management, U.S.A.
16. LITTLE, ARTHUR D., INC., 1977; Economic analysis of pesticide disposal methods, pp.19-21, EPA 540/9-77-018; Strategic Studies Unit, Environment Protection Agency, Washington D.C., U.S.A.
17. MÜNNECKE, D. M., 1979; as Note 8, p.18.
18. DIGBY, G. J. A., Agricultural and Veterinary Chemical Association, 1980; Personal communication.
19. See the following:
  - a. WORKING GROUP ON PESTICIDES, 1970; Ground disposal of pesticides: the problem and criteria for guidelines, PB 197 144, National Technical Information Service, Virginia, U.S.A.
  - b. DEPARTMENT OF THE ENVIRONMENT, 1980; as Note 2.
  - c. NOVAK, R. G. and O. H. HAMMER, 1970; Pesticide waste disposal, Part I. Down to Earth 26, 13-16.
20. DOULL, J., C. D. KLAASSEN and M. O. AMDUR, 1980; Casarett and Doull's Toxicology, p.70; Macmillan Publishing Company, Inc., New York, U.S.A.
21. WOLFE, H. R., W. F. DURHAM, K. C. WALKER, J. F. ARMSTRONG, 1961; Health hazards of discarded pesticide containers, Archives of Environmental Health 3, 45-51.
22. MOORE, E. E., 1973; Disposal of unwanted excess pesticides and empty containers, Journal of Environmental Health 36, 238-243.
23. See the following:
  - a. ARCHER, T. E., 1975; Removal of 2,4-dichlorophenoxyacetic acid (2,4-D) formulation from non-combustible pesticides containers, Bulletin of Environmental Contamination and Toxicology 13, 44-51.
  - b. ARCHER, T. E. and D. P. H. HSIEH, 1973; Detoxication of metal drums from emulsifiable concentrate formulations of parathion, Pesticide Science 4, 69-76.

24. LAMBERTON, J. G., P. A. THOMSON, J. M. WITT and M. L. DEINZER, 1976; Pesticide container decontamination by aqueous wash procedure, Bulletin of Environmental Contamination and Toxicology 16, 528-535.
25. WOLFE, H. R., et al, 1961; as Note 21.
26. GEHLBACH, S. H. and W. A. WILLIAMS, 1975; Pesticide containers. Their contribution to poisoning, Archives of Environmental Health 30, 49-50.
27. See the following:
  - a. LITTLE, ARTHUR D., INC., 1977; as Note 16, p.49.
  - b. HUSSEY, D., Ministry of Agriculture, Fisheries and Food, Harpenden Laboratories, U.K., 1980; Personal communication.
28. See the following:
  - a. AUSTRALIAN ENVIRONMENTAL COUNCIL, and CONFEDERATION OF AUSTRALIAN INDUSTRY, 1981; as Note 10.
  - b. JOHNSON, J. C., 1978; Laboratory assessment of fixation and encapsulation processes for arsenic laden wastes, in: SHULTZ, D. W. (ed.), Fourth Annual Research Symposium on Land Disposal of Hazardous Wastes, held at San Antonio, Texas, March 1978, pp.326-341, EPA 600/9-78-016; Environmental Protection Agency, Washington D.C., U.S.A.
29. See the following:
  - a. KEARNEY, P.C., E. A. WOOLSON, J. R. PLIMMER and A. R. ISENSEE, 1969; Decontamination of pesticides in soils, Residue Reviews 29, 137-149.
  - b. BURNSIDE, O. C., 1974; Prevention and detoxification of pesticide residues in soils, in: Guenzi, W. D. (ed.), Pesticides in soil and water, pp.387-412; Soil Science Society of America, Inc., Madison, Wisconsin, U.S.A.
  - c. GOMAA, H. M. and S. D. FAUST, 1974; Removal of organic pesticides from water to improve quality, in: Guenzi, W. D. (ed.), Pesticides in soil and water, pp.413-450; Soil Science Society of America, Inc., Madison, Wisconsin, U.S.A.

30. See the following:

- a. BREIDENBACH, A. W., 1970; Application of solid waste research to pesticide disposal, in: Working Group on Pesticides, Proceedings of the National Working Conference on Pesticide Disposal, held in the National Agricultural Library, Beltsville, Maryland, pp.120-123, PB 197 145; National Technical Information Service, Virginia, U.S.A.
- b. SWARTZBAUGH, J. T., R. L. HENTRICH and G. V. SABEL, 1978; Co-disposal of industrial and municipal waste in a landfill, in: SHULTZ, D. W. (ed.), Fourth Annual Research Symposium on Land Disposal of Hazardous Wastes, held at San Antonio, Texas, March 1978, pp.129-151, EPA 600/9-78-016; Environmental Protection Agency, Washington D.C., U.S.A.

31. The second part of Chapter 2 covers this area adequately for purpose of this document.

32. DEPARTMENT OF THE ENVIRONMENT, 1980; as Note 2.

33. a. ANON., 1981; Pesticides: advice and recommendations to be used by national and other authorities as well as manufacturers concerned with the registration of agricultural and non-agricultural pesticides, pp.73-79; Fifth Edition; Council of Europe, Strasbourg, France.

- b. These recommendations from the Council of Europe are aimed at countries in the European Economic Community.

34. Chemical Abstracts; American Chemical Association, and, Pesticide Abstracts, Environmental Protection Agency, U.S.A.

35. The Swedish work was carried out by B. Ahling, et al, from the Swedish Water and Air Pollution Research Institute, Stockholm. Papers were written in English and related mainly to disposal by incineration.

36. See the following:

- a. WILKINSON, R. E., G. L. KELSO and F. C. HOPKINS, 1978; State-of-the-art-report: Pesticide disposal research, 225pp and 182 refs.; prepared for Municipal Environmental Research Laboratory, Office of Research and Development, Environmental Protection Agency, Cincinnati, Ohio, U.S.A.
- b. S.C.S. ENGINEERS, 1979; Disposal of dilute pesticide solutions, 103pp and 80 ref.; SW-174c; prepared for Office of Solid Waste, Environmental Protection Agency, U.S.A.
- c. SHIH, C. C. and D. F. DAL PORTO, 1975; Hand book for pesticide disposal by common chemical methods, 93pp and 91 refs.; EPA 530/SW-112c; prepared for the Office of Solid Waste Management Programmes, Environmental Protection Agency, U.S.A.
- d. LAWLESS, E. W., T. L. FERGUSON and A. F. MEINERS, 1975; Guidelines for the disposal of small quantities of unused pesticides, 331pp and 166 ref.; EPA 670/2-75-057; prepared for National Environment Research Centre, Office of Research and Development, Environmental Protection Agency, Cincinnati, Ohio, U.S.A.

37. LAWLESS, E. W., et al, 1975; as Note 36d.

38. S.C.S. ENGINEERS, 1979; as Note 36b.

- a. DILLON, A. P. (ed.), 1981; Pesticide disposal and detoxification. Processes and techniques, Pollution Technology Review, No.81; Noyes Data Corporation, New Jersey, U.S.A.
- b. In addition to the references under Notes 36a, 36b, and 36c, this compilation contains, LANDE, S. S., 1978; Identification and description of chemical deactivation/detoxification methods for the safe disposal of selected pesticides, 166pp and 178 ref.; EPA SW-165c; prepared for the Office of Solid Waste, Environmental Protection Agency, U.S.A. This publication is largely a continuation of the work reported by Shih and Dal Porto, Note 36c.

40. See the following:
  - a. GOULDING, R. L., 1974; Waste pesticide management, 269pp; Environmental Health Sciences Centre, Oregon State University, Corvallis, U.S.A. (as cited in S.C.S. Engineers, 1979, Note 38b.)
  - b. KENNEDY, M. V. (ed.), 1978; Disposal and decontamination of pesticides, 158pp, A.C.S. Symposium Series 73; American Chemical Society, Washington D.C., U.S.A. (as taken from a book review in Journal of Environmental Quality 9, 174; 1980).
41. LITTLE, ARTHUR D., INC., 1977; as Note 16, 181pp and 36 refs.
42. MÜNNECKE, D. M., 1979; as Note 8.
43. WILKINSON, R. R., et al, 1978; as Note 36a.
44.
  - a. MÜNNECKE, D. M., 1979; as Note 8.
  - b. Terminology in the remainder of this chapter often requires more than the short explanations above, and the enquiring reader is referred to any of the standard introductory chemical texts. In general, however, the technical terms refer only to detail with which the casual reader need not concern himself.
45. WILKINSON, R. F., et al, 1978; as Note 36a.
46. See the following:
  - a. As above.
  - b. MÜNNECKE, D. M., 1979; as Note 8.
47. MÜNNECKE, D. M., 1979; as Note 8.
48. As above.
49. WILKINSON, R. R., et al, 1978; as Note 36a.
50. DEPARTMENT OF THE ENVIRONMENT, 1980; as Note 2, p.18.
51. WORKING GROUP ON PESTICIDES, 1970; Information available on disposal of surplus pesticides and empty containers, and emergency situations, PB 197 146; National Technical Information Service, Virginia, U.S.A.
52. S.C.S. ENGINEERS, 1979; as Note 36b, p.17.

53. LAWLESS, E. W., et al, 1975; as Note 36d, p.25.
54. As above; pp.25-27.
55. MINISTRY OF AGRICULTURE, FISHERIES AND FOOD, and BRITISH CROP PROTECTION COUNCIL, 1980; Guidelines for the disposal of unwanted pesticides and containers on farms and holdings, pp.6-7, Booklet 2198; Ministry of Agriculture, Fisheries and Food (Publications), Pinner, Middlesex, U.K.
56. ENVIRONMENTAL PROTECTION AGENCY, 1978; Safe storage and disposal of pesticides, pp.3-4, OPA 77/8; Office of Public Affairs, Environmental Protection Agency, Washington D.C., U.S.A. (small booklet).
57.
  - a. PESTICIDES SECTION, Department of Primary Industry, 1980; A manual of safe practice in the handling and use of pesticides, pp.218-219, 228-229, 231, PB 377; Australian Government Publishing Service, Canberra, Australia.
  - b. ANON., 1971; Disposal of containers and unwanted pesticides (wall chart); Agricultural and Veterinary Chemicals Association, Sydney, Australia. See also Appendix VII.
  - c. DEPARTMENT OF THE ENVIRONMENT, 1975; Approved method of disposal of pesticides and pesticide containers; Tasmanian Journal of Agriculture 46, 81-85.
  - d. ANON., 1979; Code of practice for safe use of pesticides, pp.20-22; Commonwealth Scientific and Industrial Research Organisation, Melbourne, Australia.
  - e. ANON., 1977; Recommendations for the control of noxious weeds in Victoria, p.5, Bulletin No. 3E, 1977; Department of Crown Lands and Survey, Victoria, Australia.
  - f. ANON., undated; Disposal of pesticide containers and surplus pesticide (wall chart); Environment Protection Authority, Victoria, Australia.
  - g. ANON., 1979; Disposal of pesticide containers and surplus pesticide, Agnote 39/79; Department of Agriculture, Victoria, Australia.
  - h. ANON., 1981; The storage and handling of pesticides, Australian Standard 2507 - 1981, p.16; Standards Association of Australia.



57. i. ANON., undated; Chemical safety, Rural Industry Safety No.6, pp.6-7; Department of Labour and Industry, Victoria, Australia.

This covers all of the known substantial(?) publications on disposal originating in Australia. It is unlikely that any omissions would add anything to the body of knowledge embraced in the publications named above.

58. ANON., 1981; as Note 33a, pp.73-79.
59. MINISTRY OF AGRICULTURE, FISHERIES AND FOOD, et al, 1980; as Note 55, pp.6-7.
60. ENVIRONMENTAL PROTECTION AGENCY, 1978; as Note 56.
61. Various; as Notes 57a, b, b, d, e, f, g, h, i.
62. ANON., 1981; as Note 33a, pp.73-79.
63. WILKINSON, R. R., et al, 1978; as Note 36a, p.196.
64. As above; p.203.
65. LAWLESS, E. W. et al, 1975; as Note 36d.
66. WORKING GROUP ON PESTICIDES, 1970; as Note 19a, p.1.
67. WORKING GROUP ON PESTICIDES, 1970; as Note 51, p.2.
68. Such facilities are available in the U.S.A., although there are not many. The offices of the U.S. E.P.A. give information on request.
69. See, for example, ANON., 1981; as Note 57h, p.16.
70. See the following:
- a. LAWLESS, E. W. et al, 1976; as Note 36d.
  - b. ANON., undated; as Note 57f.
  - c. ENVIRONMENTAL PROTECTION AGENCY, 1978; as Note 56.
71. MCDONALD, J. L., 1979; How can we dispose of unused pesticides? Pest Control 47, (12), 36-7.
72. LAVERGNE, E. A., 1974; Study of feasibility of Herbicide Orange chlorinolysis, EPA-600/2-74-006; Environmental Protection Agency, Washington D.C., U.S.A.

73. BELL, B. A. and WHITMORE, F.C., 1978; Kepone incineration test programme, EPA-600/2-78-108; Municipal Environmental Research Laboratory, Office of Research and Development, Environmental Protection Agency, Cincinnati, Ohio, U.S.A.
74. WILKINSON, R. R., et al, 1978; as Note 36a, pp.8-59.
75. MÜNNECKE, D. M., 1979; as Note 8, pp.9-10.
76. As above, p.10.
77. WILKINSON, R. R., et al, 1978; as Note 36a, p.xviii.
78. LAWLESS, E. W. et al., 1975; as Note 36d.
79. ENVIRONMENTAL PROTECTION AGENCY, 1978; as Note 56.
80. See for example:
  - a. PESTICIDES SECTION, 1980; as Note 57a, p.231.
  - b. ANON., 1971; as Note 57b.
81. ANON., 1981; as Note 33a, pp.73-79.
82. MINISTRY OF AGRICULTURE, FISHERIES AND FOOD, et al, 1980; as Note 55.
83. See the following:
  - a. HOLLOMAN, M. E., F. Y. HUTTO, M. V. KENNEDY and C R. SWANSON, 1976; Thermal degradation of selected chlorinated herbicides, Journal of Agricultural and Food Chemistry 24, 1194-1198.
  - b. STOJANOVIC, B. J., F. HUTTO, M. V. KENNEDY and F. I. SHUMAN, 1972; Mild thermal degradation of pesticides, Journal of Environmental Quality 1, 397-401.
  - c. KENNEDY, M. V., B. J. STOJANOVIC and F. L. SHUMAN, 1972; Chemical and thermal aspects of pesticide disposal, Journal of Environmental Quality 1, 63-65.
84. See the following:
  - a. LAWLESS, E. W., et al, 1975; as Note 36d.
  - b. S.C.S. ENGINEERS, 1979; as Note 36b.
  - c. SHIH, C. C., et al, 1975; as Note 36c.
  - d. LANDE, S. S., 1978; as Note 39b.
85. LAWLESS, E. W., et al, 1975; as Note 36d.

86. SHIH, C. C. and D. F. DAL PORTO, 1975; as Note 36c.
87. As above.
88. LANDE, S. S., 1978; as Note 39b.
89. Pesticides marked with an asterisk are those suggested by SHIH and DAL PORTO, 1975; as Note 36c, as suitable for alkaline hydrolysis. Others in the list are suggested by LANDE, 1978; as Note 39b.
90. Pesticides marked with an asterisk were suggested by SHIH and DAL PORTO, 1975; as Note 36c, as unsuitable for alkaline hydrolysis. Others in the list are suggested by LANDE, 1978; as Note 39b.
91. LAWLESS, E. W., et al, 1975; as Note 36d, pp.53-134.
92. MUNNECKE, D. M., 1979; as Note 8, p.6.
93. SHIH, C. C. and D. F. DAL PORTO, 1975; as Note 36c.
94. LANDE, S. S., 1978; as Note 39b.
95. LAWLESS, E. W., et al, 1975; as Note 36d.
96. SHIH, C. C. and D. F. DAL PORTO, 1975; as Note 36c.
97. LANDE, S. S., 1978; as Note 39b.
98. SHIH, C. C. and D. F. DAL PORTO, 1975; as Note 36c.
99. S.C.S. ENGINEERS, 1979; as Note 36b, p.51.
100. WILKINSON, R. R., et al, 1978; as Note 36a, p.62.
101. See the following:
  - a. WILKINSON, R. R., et al, 1978; as Note 36a, p.157.
  - b. S.C.S. ENGINEERS, 1979; as Note 36b, p.74.
102. S.C.S. ENGINEERS, 1979; as Note 36b.
103. As above.
104. As above.
105. MARSH, J. R., H. PHUNG and D. E. ROSS, 1980; as Note 7.

106. WORKING GROUP ON PESTICIDES, 1970; as Note 51, p.10.
107. GHASSEMI, M., S. C. QUINLIVAN and H. R. DAY, 1976; Landfills for pesticide waste disposal, Environmental Science and Technology 10, 1209-1214.
108. NOVAK, R. G. and O. H. HAMMER, 1970; as Note 19c.
109. S.C.S. ENGINEERS, 1979; as Note 36b.
110. The clay or organic content of soil is highly correlated with the degree of adsorption; sand, because it is low in both organic matter and clay, favours pesticide mobility. These points are explained fully in Chapter 2.
111. See the following:
  - a. ANON, 1979; Hazardous waste technology is available, Science 204, 930-933.
  - b. WILLIAMS, P. P., 1977; Metabolism of synthetic organic pesticides by anaerobic micro-organisms, Residue Reviews 66, 63-135.
112. MOORE, E. E., 1973; as Note 22.
113. WORKING GROUP ON PESTICIDES, 1970; as Note 19a, p.41.
114. See, for example, the following:
  - a. WILKINSON, R. R., et al, 1978; as Note 36a, p.173.
  - b. ANON., 1979; as Note 111a.
115. WORKING GROUP ON PESTICIDES, 1970; as Note 51, p.13.
116. HALL, C. V., J. BAKER, P. DAHM, L. FREIBURGER, G. GORDER, L. JOHNSON, G. JUNK, F. WILLIAMS, 1981; Safe disposal methods for agricultural pesticide wastes, 217pp, 37 refs., EPA 600/2-81-074, PB 81-197 584; prepared for Municipal Environmental Research Laboratory, Office of Research and Development, Environmental Protection Agency, Cincinnati, Ohio, U.S.A.
117. As above, p.2.
118. JOHNSON, L. M. and P. A. HARTMAN, 1980; Microbiology of a pesticide disposal pit, Bulletin of Environmental Contamination and Toxicology 25, 448-455.

119. S.C.S. ENGINEERS, 1979; as Note 36b, pp.29 and 32.
120. As above, p.32.
121. GILLHAM, J., 1980; Safe disposal of used sheep dip, Farm Notes 34/80; Department of Agriculture, Tasmania, Australia. See also Appendix VIII.
122. S.C.S. ENGINEERS, 1979; as Note 36b, p.60.
123. WILKINSON, R. R., et al, 1978; as Note 36a, p.78.
124. a. JACOBSON, S. N. and M. ALEXANDER, 1981; Enhancement of the microbial dehalogenation of a model chlorinated compound, Applied and Environmental Microbiology 42, 1062-1066.  
b. DI GERONIMO, M. J., M. NIKAIDO and M. ALEXANDER, 1979; Utilization of chlorobenzoates by microbial populations in sewage, Applied and Environmental Microbiology 37, 619-625.
125. a. MULLINS, D. E., J. A. PETRUSKA, R. W. NICHOLSON, E. R. COLLINS and R. W. YOUNG, 1981; Preliminary studies evaluating composting as a means for pesticide disposal in: Schultz, D. (ed.), Seventh Annual Research Symposium on Land Disposal of Hazardous Wastes, held at Philadelphia, Ohio, U.S.A. Pennsylvania, March 1981, pp.283-290, EPA-600/9-81-002b, PB81-173 882; Environmental Protection Agency, U.S.A.
126. WILKINSON, R. R., et al, 1978; as Note 36a, pp.72-74.
127. PEMBERTON, J. M., 1981; Genetic engineering and biological detoxification of environmental pollutants, Residue Reviews 78, 1-11.
128. PEMBERTON, J. M. and R. H. DON, 1981; Bacterial plasmids of agricultural and environmental importance, Agriculture and Environment 6, 23-32.
129. S.C.S. ENGINEERS, 1979; as Note 36b, p.40.
130. As above, p.44.
131. As above.
132. LAWLESS, E. W., et al, 1975; as Note 36d, pp.324-326.
133. As above, p.325.

134. As above, p.326.
135. As above, pp.v-vi.
136. S.C.S. ENGINEERS, 1979; as Note 36b, pp.74-91.
137. ENVIRONMENTAL PROTECTION AGENCY, 1978; as Note 56.
138. As above.
139. LAWLESS, E. W., et al, 1975; as Note 36d.
140. BRAMBLEY, J. and D. KOLLIAS, 1980; Study of current label statements on pesticide disposal and storage, in: Treatment of Hazardous Waste, Proceedings of the Sixth Annual Research Symposium, Chicago, March 1980, pp.101-111, EPA 600/9-80-011, PB 80-175 094; prepared for Municipal Environmental Research Laboratory, Research and Development, Environmental Protection Agency, Cincinnati, Ohio, U.S.A.
141. DEPARTMENT OF THE ENVIRONMENT, 1980; as Note 2, pp.20-21.
142. MINISTRY OF AGRICULTURE, FISHERIES AND FOOD, et al, 1980; as Note 55, pp.5-7.
143. As above, p.5.
144. DEPARTMENT OF THE ENVIRONMENT, 1980; as Note 2, p.21.
145. ANON., 1979; Pesticides Safety Precautions Scheme, agreed between Government Departments and Industrial Associations; Appendix E, Guidelines on the classification and labelling of pesticide products.
146. ANON., 1981; as Note 36a, pp.77-78.
147. STEIGER, J., 1978; Pesticide disposal research, Pest Control 45, (11), 56-60.
148. GIFAP is the international association of national agrochemical associations. GIFAP = Groupement International des Associations Nationales de Fabricants de Produit Agrochimique.

149. See, for example:
  - a. ANON., 1979; as Note 57g.
  - b. DEPARTMENT OF THE ENVIRONMENT, 1975; as Note 57c.
  - c. CATT, M. J., 1980; Safety first, Part 2: Hints on the safe storage and handling of herbicides and disposal of empty containers, in: Herbicides for weed control in South Australia; Department of Agriculture, South Australia.
150. Pesticides Section, 1980; as Note 57a.
151. See, for example:
  - a. DEPARTMENT OF THE ENVIRONMENT, 1975; as Note 57c.
  - b. ANON., undated; as Note 57f.
152. ANON., 1977; as Note 57a.
153. ANON., 1979; as Note 57d.
154. ANON., 1971; as Note 57b.
155. ANON., 1981; as Note 57h.
156. In seeking information for this general project, exploratory letters, which included a request for at least two or three sample pesticide labels, were sent to twenty nine pesticide manufacturers. Fourteen companies responded with a total of seventy nine different labels.
157. ANON., 1968; Pesticides: disposing of containers and unwanted pesticides, PB 17; Department of Primary Industry, Canberra, Australia.
158. GILLHAM, J., 1980; as Note 121.
159. HALL, C. V., et al, 1981; as Note 116.
160. Personal communication with various State registration authorities clarified this legal requirement.
161. SNELSON, J., Pesticides Section, Department of Primary Industry, Canberra, 1981; Personal communication.
162. SHORT, J., Department of Agriculture, Tasmania, 1980; Personal communication.
163. SHIH, C. C. and D. F. DAL PORTO, 1975; as Note 36c.

164. LANDE, S. S., 1978; as Note 39b.
165. The reasons for alkaline hydrolysis being inappropriate include lack of knowledge of the extent of degradation and of the nature of the breakdown-products, as outlined earlier in the chapter. See also p.44 in the text.
166. A list of active ingredients susceptible to acid-hydrolysis is shown on p.45 . This list has been compiled from LAWLESS, E. W., et al, 1975; as Note 36d, pp.228-296.
167. In 1979, the proportion of sales value of pesticides and animal ectoparasiticides accounted for by organophosphorus compounds was at its peak and is now decreasing.
168. LAWLESS, E. W., et al, 1975; as Note 36d, pp.315-316.
169. MOORE, E. E., 1973; as Note 112, p.239.
170. As Notes 36a, b, c, d and 39b.
171. LAWLESS, E. W., et al, 1975; as Note 36d, pp.327-329.
172. MÜNNECKE, D. M., 1979; as Note 8, p.18.
173. LANGE, S. S., 1978; as Note 39b, pp.571-575.
174. LITTLE, ARTHUR D., INC., 1977; as Note 16, see, for example pp.22-29, and 125-136.
175. STATON, W. S., J. G. LAMPERTON and H. R. DAY, 1976; Pesticide container processing in commercial reconditioning facilities, EPA/530-SW-534; prepared for Solid Waste Information, Environmental Protection Agency, Cincinnati, Ohio, U.S.A.
176. ARCHER, T. E., 1975; as Note 23a.
177. ARCHER, T. E. and D. P. H. HSIEH, 1973; as Note 23b.
178. WORKING GROUP ON PESTICIDES, 1970; as Note 51, p.25.
179. LAWLESS, E. W., et al, 1975; as Note 36d, p.327.



180. See the following:

- a. SUBCOMMITTEE ON CONTAINER DISPOSAL, and SPECIFICATION OF THE GOOD OPERATING PRACTICES COMMITTEE, National Agricultural Chemical Association, undated; Disposing of pesticide containers; National Agriculture Chemicals Association, Washington D.C., U.S.A. (small booklet).
- b. ENVIRONMENTAL PROTECTION AGENCY, 1978; as Note 56.
- c. ANON., 1979; Position papers; National Agricultural Chemicals Association, Washington D.C., U.S.A.

181. VON RUMKE, R. and F. HORAY, 1972; Pesticide manual, Part I, p.42, Contract No. AID/csd 3296; Regents of the University of California, Davis, California, U.S.A.

182. BRAMBLEY, J. and D. KOLLIAS, 1980; as Note 140.

183. DEPARTMENT OF THE ENVIRONMENT, 1980; as Note 2, pp.29-31.

184. MINISTRY FOR AGRICULTURE, FISHERIES AND FOOD, et al, 1980; as Notes 55, pp.3, 4, 6.

185. BRITISH CROP PROTECTION COUNCIL, 1977; Guidelines for the safe disposal of unwanted pesticides and used containers from stores of local authorities, agricultural merchants and agricultural spraying contractors; British Crop Protection Council, London, U.K.

186. ANON., 1981; as Note 33a, p.76.

187. As Notes 57a, b, c, d, e, f, g, h, i. See also Appendix VII.

188. Personal communication with various State registration authorities clarified these legal requirements.

189. ENVIRONMENTAL PROTECTION AGENCY, 1978; as Note 56.

190. SUBCOMMITTEE ON CONTAINER DISPOSAL, and SPECIFICATION OF THE GOOD OPERATING PRACTICES COMMITTEE, undated; as Note 180a.

191. NOVAK, R. G. and O. H. HAMMER, 1970; as Note 19c.

192. See the following:
  - a. SUBCOMMITTEE ON CONTAINER DISPOSAL, and SPECIFICATION OF THE GOOD OPERATING PRACTICES COMMITTEE, National Agricultural Chemical Association, undated; as Note 180a.
  - b. ENVIRONMENTAL PROTECTION AGENCY, 1978; as Note 56.
  - c. VON RÜMKE, R. and F. HORAY, 1972; as Note 181.
  - d. ANON., 1979; as Note 180c.
193. BRAMBLEY, J. and D. KOLLIAS, 1980; as Note 140.
194. MINISTRY OF AGRICULTURE, FISHERIES AND FOOD, et al, 1980; as Note 55, p.10.
195. See the following:
  - a. MINISTRY OF AGRICULTURE, FISHERIES AND FOOD, et al, 1980; as Note 55, p.4.
  - b. DEPARTMENT OF THE ENVIRONMENT, 1980; as Note 2, p.30.
196. ANON., 1979; as Note 145.
197. ANON., 1981; as Note 33a, p.76.
198. See, for example: ANON., 1971; as Note 57b.
199. SUBCOMMITTEE ON CONTAINER DISPOSAL, and SPECIFICATION OF THE GOOD OPERATING PRACTICES COMMITTEE, National Agricultural Chemicals Association; as Note 180a.
200. Personal communication with various State registration authorities clarified these legal requirements.
201. ENVIRONMENTAL PROTECTION AGENCY, 1978; as Note 56.
202. BRAMBLEY, J. and D. KOLLIAS, 1980; as Note 140.
203. MINISTRY OF AGRICULTURE, FISHERIES AND FOOD, et al, 1980; as Note 55, p.3.
204. ANON., 1979; as Note 145.
205. ANON., 1981; as Note 33a, pp.74-75.
206. ANON., 1981; as Note 57h, p.9.
207. PESTICIDES SECTION, Department of Primary Industry, 1980; as Note 57a, pp.209-218.

208. ANON., 1980; Farm storage of agrivet chemicals, AVCACode No.2; Agricultural and Veterinary Chemicals Association, Sydney, Australia. (wall chart).
209. ANON., 1979; as Note 57d, p.9.
210. LITTLE, ARTHUR D., INC., 1977; as Note 16, p.161.
211. As above.
212. As above, pp.164-165..
213. Intermediate compounds in this context are compounds which differ from both the initial compound and the desired end results, but which, in terms of the chemical reaction in question, lie somewhere in between.
214. LITTLE, ARTHUR D., INC., 1977; as Note 16, p.165.
215. WOLFE, H. R., et al, 1961; as Note 25.
216. LITTLE, ARTHUR D., INC., 1977; as Note 16, p.165.
217. WILKINSON, R. R., et al, 1978; as Note 36a, p.45.
218. TABOR, E. C., 1970; Air pollution problems of pesticide disposal, in: Working Group on Pesticides, Proceedings of the National Working Conference on Pesticide Disposal, held at the National Agricultural Library, Beltsville, Maryland in June/July 1970, pp.99-100, PB 197 145; National Technical Information Service, Virginia, U.S.A.
219. KENNEDY, M. V., G. J. STOJANOVIC and F. L. SHUMAN, 1972; Analysis of decomposition products of pesticides, Journal of Agricultural and Food Chemistry 20, 341-343.
220. WILKINSON, R. R., et al, 1978; as Note 36a, p.50.
221. SHIH, C. C. and D. F. DAL PORTO, 1975; as Note 36c.
222. LANDE, S. S., 1978; as Note 39b.
223. LAWLESS, E. W., et al, 1975; as Note 36d.
224. See the following:
  - a. SHIH, C. C. and D. F. DAL PORTO, 1975; as Note 36c.
  - b. LANDE, S. S. 1978; as Note 39b.

225. LAWLESS, E. W., et al, 1975; as Note 36d.
226. See, for example:
- a. ANON., 1971; as Note 57b.
  - b. PESTICIDES SECTION, Department of Primary Industry, 1980; as Note 57a, p.231.
227. As Notes 23a, 23b and 175.
228. WORKING GROUP ON PESTICIDES, 1970; as Note 19a, p.6.
229. See the following:
- a. LITTLE, ARTHUR D., INC., 1977; as Note 16.
  - b. WORKING GROUP ON PESTICIDES, 1970; as Note 19a.
  - c. BURMASTER, D. E., 1982; The new pollution - groundwater contamination, Environment 24, 6-13, 33-6.
  - d. CLARK, C. S., C. R. MEYER, P. S. GARTSIDE, V. A. MAJETI, B. SPECKER, W. F. BALISTRERI and V. J. ELIA, 1982; An environmental health survey of drinking water contamination by leachate from a pesticide waste dump in Hardeman County, Tennessee, Archives of Environmental Health 37, 9-17.
230. a. KNIGHT, M. J., J. T. LEONARD and R. J. WHITELEY, 1978; Lucas Heights solid waste landfill downstream leachate transport, Bulletin of the International Association of Engineer Geologists 18, 45-64.
- b. KNIGHT, M. J., J. T. LEONARD and R. J. WHITELEY, 1978; A hydrological assessment of the Lucas Heights landfill, Waste Disposal and Water Management in Australia 5, 10-24.
- c. LEONARD, J. G. 1977; Hydrogeology and hydrochemistry of the Lucas Heights waste disposal sites, and extent of leachate transport in tributaries of St. George's River; Project report for Master of Applied Science, University of New South Wales, Australia.
231. STOJANOVIC, B. J., M. V. KENNEDY and F. L. SHUMAN, 1972; Edaphic effects of the disposal of unused pesticides, pesticide wastes and pesticide containers, Journal of Environmental Quality 1, 54-62.
232. As above.

233. DAVIDSON, J. M., L. OU and P. S. C. RAO, 1978; Adsorption, movement and biological degradation of high concentrations of selected pesticides in soils, in: Schultz, D. W. (ed.), Fourth Annual Research Symposium on Land Disposal of Hazardous Wastes, held at San Antonio, Texas, March 1978, pp.233-244, EPA 600/9-78-016, Environmental Protection Agency, Washington D.C., U.S.A.
234. Actinomycetes are a characteristic group of soil bacteria, one part of which is the genus Streptomyces.
235. STOJANOVIC, B. J., et al, 1972; as Note 231.
236. LITTLE, ARTHUR D., INC., 1977; as Note 16.
237. WILKINSON, R. R., et al, 1978; as Note 36a, p.171.
238. Predators of pests as well as diseases of pests can be very effective in controlling populations of pests.
239. See the following:
- a. LEWIS, R. G. and R. E. LEE JNR., 1976; Air pollution from pesticides: sources, occurrence and dispersion, in: Lee, R. E. Jnr., (ed.), Air pollution from pesticides and agricultural processes, p.20; C.R.C. Press, Inc., Cleveland, Ohio, U.S.A.
  - b. WILKINSON, R. R., et al, 1978; as Note 36a, p.171.
240. See the following:
- a. WILKINSON, R. R., et al, 1978; as Note 36a, p.158.
  - b. GHASSEMI, M., et al, 1976; as Note 107.
241. S.C.S. ENGINEERS, 1979; as Note 36b, p.25.
242. JANSEN, L. L., 1970; as Note 14a, pp.35.
243. LITTLE, ARTHUR D., INC., 1977; as Note 16, pp.123-160.
244. JANSEN, L. L., 1970; as Note 14a, p.35.
245. LITTLE, ARTHUR D., INC., 1977; as Note 16, p.126.
246. JANSEN, L. L., 1970; as Note 14a, p.35.
247. LITTLE, ARTHUR D., INC., 1977; as Note 16, pp.123-60.
248. JANSEN, L. L., 1970; as Note 14a, p.35.

249. LITTLE, ARTHUR D., INC., 1977; as Note 16, p.128.
250. a. S.C.S. ENGINEERS, 1979; as Note 36b, pp.35, 36, 45 and 69.  
b. It is worthy of note that the authors did not include cost of the disposal method as one of the bases of comparison. MÜNNECKE, 1979, as Note 8, by contrast, emphasized cost as an important aspect of disposal.
251. The cost of the evaporation basin was given as US\$22.01 per cubic metre of solution, in 1979. On the basis of exchange rates at the time (1.12 in June 1979) and changes in the Consumer Price Index (9.2% in 1980 and 11.3% in 1981), this indicates a cost of approximately A\$24 per cubic metre treated.
252. WILKINSON, R. R., et al, 1978; as Note 36a.
253. MÜNNECKE, D. M., 1979; as Note 8, p.19.
254. JANSEN, L. L., 1970; as Note 14a.
255. GHASSEMI, M., et al, 1976; as Note 107.
256. LITTLE, ARTHUR D., INC., 1977; as Note 16.
257. ANON., 1978; Federal Insecticide, Fungicide and Rodenticide Act as amended, OPA 17/9; Office of Pesticide Programmes, Environmental Protection Agency, Washington D.C., U.S.A.
258. ANON., 1981? Regulations for the acceptance of certain pesticides and recommended procedures for the disposal and storage of pesticides and pesticide containers; Code of Federal Regulations, Part 165.
259. OFFICE OF SOLID WASTE MANAGEMENT PROGRAMMES, Environmental Protection Agency, 1974; Disposal of hazardous wastes: report to Congress, SW-115; Environmental Protection Agency, Washington D.C., U.S.A.
260. ANON., 1981? as Note 258.
261. ANON., 1981; EPA regulations under consideration, Federal Register 46, 53993.

262. These three Acts are:

- i. The Deposit of Poisonous Waste Act, 1972, and Regulations,
- ii. The Control of Pollution Act, 1974, and
- iii. The Health and Safety at Work, etc., Act 1974; and the Health and Safety (Agriculture) (Poisonous Substances) Regulations, 1975.

263. ANON., 1979; as Note 145.

264. The Technical Committee on Agricultural Chemicals comprises one senior government official from each State and a representative of the National Health and Medical Research Council. The chairman of this Committee is the (federal) Department of Primary Industry's Pesticide Co-ordinator. The Secretariat is provided by and located in the (federal) Department of Primary Industry in Canberra.

265. A more detailed outline of the product registration procedure and requirements, and of the function of the Technical Committee on Agricultural Chemicals, may be found, for example in -

- a. PESTICIDES SECTION, 1980; as Note 57a.
- b. TECHNICAL COMMITTEE ON VETERINARY DRUGS, Department of Primary Industry, Canberra, 1979; Requirements for clearance of veterinary drugs, PB 92B; Australian Government Publishing Service, Canberra, Australia.
- c. TECHNICAL COMMITTEE ON AGRICULTURAL CHEMICALS, Department of Primary Industry, Canberra, 1979; Requirements for clearance of agricultural chemicals, PB 310; Australian Government Publishing Service, Canberra, Australia.
- d. BELCHER, R. S., 1980; Assessment of agricultural chemicals before registration in Victoria, Agnote 1324/80; Department of Agriculture, Victoria.

266. ANON., 1979; Pesticides Act, 1978, No.57, [New South Wales] Section 31(c), p.30; Government Printer, Sydney, New South Wales, Australia.

267. As above, Section 21, 1, (c), (i), p.23.

268. ANON., 1969; Pesticides Regulations, 1969, [Tasmania] Statutory Rules No.217, Part V, Section 20, p.8; Government Printer, Hobart, Tasmania, Australia.
269. As above, Part V, Section 16,(2).
270. NORMAN, M., Department of Health, Tasmania, 1982; Personal communication.
271. ANON., 1980; Environment Protection Act, 1973, [Tasmania] Section 15,(1); Government Printer, Hobart, Tasmania, Australia.
272. As above, Section 15,(2).
273. As above, Section 15,(3).
274. As above, Section 17,(1).
275.
  - a. ANON., 1974; Statutory Rules 1974, No. 225: Environment Protection (Waste Disposal) Amendment Regulations 1974, Section 2; gazetted 25 September 1974.
  - b. For the method approved by the Director, see Note 57c.
276. MUNGOMERY, W. V., Department of Primary Industry, Queensland, 1982; Personal communication.
277. MATTHEWS, D. C., Department of Agriculture, Victoria, 1982; Personal communication.
278. Enquiries of registration authorities in these two States elicited no response.



## CHAPTER 4

### THE FARMER SURVEY:

#### RATIONALE, RESULTS AND DISCUSSION

This chapter outlines, firstly, the general reasons for conducting a survey of pesticide and container disposal and storage on Tasmanian farms. Three fundamental questions which must be asked are suggested, and the development of these three questions into the framework of a questionnaire is discussed. Secondly, the results of the farmer survey in Tasmania are summarized and compared with related findings from other Australian research. Also, the results of research on disposal not directly related to the survey are presented. Finally, implications of the total findings are discussed.

#### 4.1 RATIONALE

Whilst pesticides are perennial objects of fear and protest in the community, these negative attitudes are generally related to the normal use of pesticides, i.e., to the application of pesticides to large areas of agricultural, forest and other land. The disposal of pesticides and pesticide containers, particularly by farmers, represents another method of release of pesticides into the environment, and therefore another source of potential damage to Man and the natural environment. To date, the practice of pesticide and container disposal has not aroused the public ire, despite the established potential for harm, particularly from pesticide concentrates<sup>1</sup>. Whilst there exists little reason to suspect a major problem surrounding these aspects of pesticide handling, disposal of pesticide and particularly of pesticide containers is a task which would frequently confront the vast majority of Tasmanian and Australian farmers. It seemed worthwhile, therefore, to make an assessment of this potential problem, particularly as virtually no work has been done previously in Australia.

An effective overall assessment of pesticide and container disposal and storage requires complete answers to three basic questions. These

questions are presented below together with brief comment, where necessary, on what information is required to answer each. Brief reference is made also to any relevant Australian contribution in each area in order to highlight the vast gaps in existing knowledge. These contributions are explained more fully later in the chapter.

- a. *What does the farmer do with waste pesticides and containers and how does he store his pesticides?* Full and accurate answering of this question is possible only by on-farm assessment. A small amount of related research into farmer practices has been carried out in Victoria by Nancarrow<sup>2</sup>, and in New South Wales by the Department of Agriculture<sup>3</sup>.
- b. *What is the magnitude of the problem, and what are the consequences of these practices (or their absence)?* Again, satisfactory answering of the question requires on-farm assessment of practices. Whilst one assessment of container accumulation in Australia has been made, it had limited application to the farm situation<sup>4</sup>. A study of leachate from an urban municipal waste disposal site is, however, pertinent to this project<sup>5</sup>. Indirect contributions to this field are contained in the more general publications on the effects of pesticides in the Australian environment, as outlined in Chapter 2.
- c. *What are the factors which combine to produce the actual practices of the farmer?* Recognizing firstly, that an answer to this question requires an excursion into behavioural sciences, sociology and psychology, and secondly, that the author's knowledge of these disciplines is limited, it seemed prudent to adopt a simplistic approach to this question.

Citing Lewin, Rowan<sup>6</sup> noted that the behaviour of an organism is a function of internal factors in that organism, and of its external environment. In the case of the farmer (the organism), and his disposal and storage practices, there is a partial intermingling of the external and internal. External factors influencing his behaviour in this context may include such

factors as legal restraints, information and advice to which he is exposed, or the influence in a number of ways of the people around him. More mundane external factors may also be operative, such as changed circumstances requiring new or renewed safety precautions, or opening of a new tip in the district. No Australian study of the effects of the law on pesticide handling has been carried out, although in New South Wales, there has been a short study of farmers' knowledge of that State's Pesticide Act<sup>7</sup>. Both Nancarrow<sup>8</sup> and the New South Wales Department of Agriculture<sup>9</sup> have assessed farmer sources of general information on pesticides, although little comment on information quality was made. Rural sociology studies in Australia have established clearly the existence of 'influencers' in the rural community<sup>10</sup>, but not specifically their significance in the context of pesticides or their disposal.

Internal factors influencing behaviour include such things as knowledge, attitudes, values and motivation. Possession of appropriate knowledge, whilst a pre-requisite for correct disposal and storage practice, is no assurance of correct practice, and must be seen only as one determinant of behaviour. Aspects of farmers' general and specific knowledge of pesticides have been assessed by the New South Wales Department of Agriculture<sup>11</sup> and Nancarrow<sup>12</sup>, but there has been no assessment of knowledge of disposal or storage. General attitudes of farmers towards pesticides have received some attention from the New South Wales Department of Agriculture<sup>13</sup>, and on an Australia-wide basis, from Cribb<sup>14</sup>. However, whilst attitudes may be a component, they are not a good indication of likely behaviour<sup>15</sup>. Values, which together with beliefs form attitudes<sup>16</sup>, and which themselves are a product of internal and external factors, are seen as standards to guide actions, make decisions and resolve conflicts<sup>17</sup>. Hawkins et al<sup>18</sup> have studied the values of farmers in south-east Australia, and there is a little applicable in this study to use and handling of pesticides. In a general sense, motivation as it applies to farmers, has been explained within Rogers' theories of

diffusion of innovation<sup>19</sup>. However, these theories do not hold when applied to such areas as conservation, and use and handling of pesticides<sup>20</sup>, and it is therefore necessary to look more generally at motivation theory. General motivation theory revolves around abundance-motivation (maximization of fresh stimulation and new experience) and deficiency-motivation (avoidance and rectification of deficiency of one's being) also described respectively as tension-seeking and -reducing motivation<sup>21</sup>. Applying this to disposal and storage situations, it is easy to see situations which would motivate practices which reduce tension: for example, the removal of threat of harm to humans and commercial livestock, elimination of the visually unpleasant heap of containers or of functionally inadequate storage, or avoidance of legal penalty or social condemnation arising from poor disposal practice. Tension-seeking or abundance motivation may be satisfied by acquisition of new and useful knowledge, or by a 'job well done'. Less than perfect behaviour may perhaps be explained by sets of values which do not fully motivate good practice, but explanation of indifferent or outright irresponsibility is difficult, and the origins may be complex.

Provision for assessment of all of these factors was made in the questionnaire, a compressed copy of which may be seen between Pages 172 - 178. The section which follows summarizes the detailed account of the survey results appearing in the Annexe, and compares findings with other research in Australia.

#### 4.2 RESULTS OF THE SURVEY

It has been noted above that the purposes of the farmer survey were to clarify three basic aspects of pesticide handling: the methods of pesticide and container disposal and storage that the farmer uses; the magnitude of any problem, and what the consequences of these practices are; and why the farmer has adopted certain practices. Attention has been drawn also to the fact that research on this problem in Australia has been scarce and, in fact, surveys of this nature seem rare anywhere<sup>22</sup>. Any study carried out now, therefore would be the first of its type and

exploratory in its nature. For this reason, it is appropriate that this study has been broader in its coverage than it is deep, and more qualitative in its presentation than quantitative. This document is primarily concerned with pesticides in the environment, and there is no argument with those who claim that its overall treatment of psychological, statistical, sociological and other aspects could have been more rigorous.

#### 4.2.1 Sources of information

Sources of information were surveyed in order to establish the channels used, and what sources are credible for the farmer. Specific sources also were examined to determine what exposure, if any, the subjects had had to information on disposal and storage. In relation to sources of general information on pesticides, officers of the State Department of Agriculture proved to be the most important, followed by distributors and then the manufacturer. A total of 58% of subjects said that Departmental officers were their most, or second most important source of pesticide information, and in nine of the 13 Department-designated districts, officers were the most important source. These three sources together were the most, or second most important source of information for 85% of farmers interviewed. Surveys of farmers' sources of information about pesticides have also been carried out by Nancarrow<sup>23</sup> and the New South Wales Department of Agriculture<sup>24</sup>. Nancarrow<sup>25</sup> found importance of information sources very similar to the author's survey (henceforth, the Tasmanian survey), namely, officers of the (Victorian) Department of Agriculture, distributors, and the manufacturer, in that order. The survey of information sources carried out in New South Wales (henceforth, the N.S.W. survey) looked more at each source rather than their relative importance<sup>26</sup>. In the Tasmanian survey, only 57% of farmers interviewed were happy with the quantity or quality of information on pesticides which they received overall, but it must be pointed out that these deficiencies were largely a result of the farmers' reluctance to make the necessary effort. The single most commonly mentioned deficiency related to information on potential harm to humans, but most perceived shortcomings related to practical issues (e.g., timing of application, which product is best, etc.). None complained about lack of information on disposal and storage until later in the interview when the subject was specifically raised.

The accuracy of manufacturers' information was questioned on a number of occasions. The relatively frequent suggestion, that independent authorities publish booklets giving all necessary details (e.g., application, precautions, etc.), was not original, and also overlooked the recommendation made by the Department in its many publications<sup>27</sup>. Another suggestion was also for a booklet on general aspects of pesticides, and this may have merit. In Nancarrow's survey<sup>28</sup>, only 17% of interviewees expressed dissatisfaction with their information sources, whereas the N.S.W. survey<sup>29</sup> did not examine overall satisfaction with quality or quantity of information available. From the poll conducted by Cribb<sup>30</sup>, it was reported that 45% of Tasmanians surveyed (and 44% nationally) believed that the press and the media "over-exaggerated the dangers of farm chemicals and pesticides". Specific recurring points of dissatisfaction in the Tasmanian survey were the problems experienced with metrication, and the unintelligible scheduling system used for coding pesticides according to degree of hazard.

Sources of information relating specifically to disposal and storage were difficult to assess. The author could find evidence of only three publications outlining disposal procedure: the Tasmanian Journal of Agriculture published an article in May 1975<sup>31</sup>, the wall chart printed by the Agricultural and Veterinary Chemicals Association<sup>32</sup>, and an article which appeared in the Huonville Department of Agriculture monthly newsletter<sup>33</sup>. Of these, only two were generally available to farmers. Whilst 49% of farmers claimed they had seen or heard information on disposal techniques, none referred specifically to any of the three sources mentioned, and only a small proportion could have been exposed to the two pieces of Departmental information. A significant number claimed they had seen information on the container label but this is a poor source (see Chapter 3). The assessment overall was that the farmer had been poorly informed. The 57% of interviewees who claimed to have seen information on storage method quoted sources similar to those for disposal. However, in this case the label is an adequate source. The main sources of information on treatment of poisoning were, in descending order of importance, the local doctor, the container label, the hospital and the Poisons Information Centre (in Hobart). The best of these sources are the label and the Poisons Information Centre, but 26% of farmers mentioned neither one nor the other. The N.S.W. survey<sup>34</sup> considered among other things, the source of information on a specific aspect

of safety (namely, clothing). In this case, the container label was found to be the most important source, with Departmental leaflets or officers, the manufacturers' leaflets and the distributor, less so. The N.S.W. survey<sup>35</sup> examined also farmers' assessments of ease of understanding, and of reliability of information sources. Although the relative importance of each was not assessed, Departmental officers, other farmers and A.B.C. Radio, the three best understood and most reliable, also rated high in overall importance as sources of general and pesticide information. Neither radio nor other farmers were so important in Tasmania as sources of pesticide information.

#### 4.2.2 Attitudes

Attitudes of the farmers surveyed in Tasmania, were partly positive, and 89% believed the use of pesticides to be essential for successful farming or production on the property; a further 88% had no ethical objections to the use of pesticides, and 87% believe they have made a significant contribution to agriculture in Australia. However, on the negative side, 88% and 90% respectively expressed the preference for the use of no pesticides on their own property, or on any property. There was also evidence suggesting that a certain unquantifiable proportion of farmers not exceeding 54%, believed that pesticides are over-used. Obviously, the farmer experiences some conflict over the use of pesticides, a conflict which is probably resolved, if not removed, by the financial gains derived from pesticide use. This view receives some support in the study by Hawkins et al<sup>36</sup> of the values of farmers in south-eastern Australia. It was found that the highest terminal value<sup>37</sup> held by interviewees was family security, and that 'a world of beauty' was very low on the scale of values. The top two instrumental values<sup>38</sup> were ambition and honesty.

If there appears some contradiction in the attitudes expressed above, there is also a consistency of attitude about who suffers any ill-effects of pesticide use. The farmer is resigned to acceptance of potential and actual undesired effects of neighbour's use, as well as his own use. On the other hand, the problems arising from under-use of pesticides by neighbours (e.g., spreading weeds or ectoparasites of animals) were less palatable. One of the more tantalizing aspects of the attitude survey

was the discussion on the matter of ethics, where it was found that both those with ethical objections to use of pesticides, and those without, qualified their stand with similar statements. More frequent among the comments passed during the attitude assessment, were some relating to the alleged effects of 2,4,5-T, and also the organophosphorus compounds. It was clear also that concern was felt by interviewees because of the gaps in the general body of pesticide toxicology, let alone in their own knowledge.

Twenty per cent of those interviewed were aware of people in the family or community who espoused strong views - invariably negative - about pesticides. Holders of these views were most commonly neighbours and organic farmers. The central-north and north-west of the State harboured most such people, but their role in attitude formation was unclear.

Both the N.S.W. survey<sup>39</sup> and Cribb<sup>40</sup> assessed farmer attitudes towards pesticides. Assessors in the N.S.W. survey<sup>41</sup> classified 42% of interviewees as pro-pesticide. Cribb<sup>42</sup> asked whether the farmer approved of today's extensive use of man-made chemicals and pesticides, and found 55% approval among Tasmanian interviewees (71% nationally). As mentioned, the Tasmanian survey found that 89% of farmers interviewed believed pesticides to be necessary for successful farming, whereas Cribb<sup>43</sup> found 69% of Tasmanian farmers responding to the poll (78% nationally) to believe pesticides to be necessary or very necessary. Cribb's<sup>44</sup> finding, that 3% of Tasmanian farmers surveyed (7% nationally) believe not enough pesticide is used, differs a lot from the finding of the Tasmanian survey, that 54% do not believe sufficient is being used. An interesting comment (in the light of what follows below) was Cribb's<sup>45</sup> finding that 71% of Tasmanian's responding to the poll were dissatisfied with current precautions (undefined) against chemical residues in farmland and the environment. Finally, it was instructive to note that, of the ten questions asked farmers in the Cribb poll<sup>46</sup>, with one exception, the responses from Tasmania were the most conservative of all States. Further work on attitudes towards pesticides has been carried out by Beal et al<sup>47</sup> in the United States.



#### 4.2.3 Knowledge

Because knowledge influences practice of any given task, the farmers' knowledge about pesticide poisoning, disposal of wastes, storage of pesticides, the harmful effects of pesticides, and the law was assessed. Overall, 75% of farmers attributed pesticides with the potential to cause undesirable effects. Their detailed knowledge of these effects was assessed using both open and closed questions, and the perceived undesirable effects volunteered in the open-ended question, were predominantly concerned with the immediate well-being of humans: effects relating to his health, his running of the farm or his financial welfare accounted for nearly 60% of effects described. Comments were generally rational although hyperbole was encountered. The relative completeness of the collective list of undesirable effects (see Chapter 2) is a comment on the overall scope of information of this type which has been disseminated among farmers in Tasmania. The closed question assessment gave farmers a score of 56% for knowledge of undesired effects.

The N.S.W. survey<sup>48</sup> examined perceived problems and disadvantages (as well as advantages) of pesticide use - a slightly different approach to that in the Tasmanian survey. Cost ranked highest in the farmers' mind followed by health hazards, contamination of, and residue build-up in the environment, and destruction of beneficial species of animal. Analysis in the two surveys was different, but a regrouping of items in the Tasmanian survey results in great similarity of the first four items in both States; namely, adverse effects on humans, on non-target insects as well as predators and parasites, on commercial livestock and on children.

Farmers' knowledge of symptoms of poisoning as revealed by the Tasmanian survey, was poor. Many were able to name the more obvious symptoms, but these could be indicative of many different conditions unrelated to poisoning. In Nancarrow's study<sup>49</sup>, 16% of interviewees stated that they could not recognize symptoms of poisoning, and both findings were echoed by Moulds<sup>50</sup>, who had had experience of both farmers and doctors not associating symptoms with cause. The symptoms named by farmers in Nancarrow's study<sup>51</sup> resembled closely those named in the Tasmanian survey, and were equally general. Incidences of human poisoning on properties of the interviewees in the Nancarrow study<sup>52</sup> and the Tasmanian survey were 16% and 15% respectively.

Knowledge of treatment of poisoning by pesticides among the Tasmanian subjects was poor, and only 35% volunteered some type of treatment by themselves. At best, 5 - 10% of interviewees would have been able to treat effectively a case of poisoning without advice or literature of some type. The Tasmanian and N.S.W. surveys<sup>53</sup> both showed a heavy dependency among farmers on medical aid for effective treatment of poisoning, and a reluctance to take own measures. In practical terms, this probably does not matter greatly, because the relatively close settlement of much of rural Tasmania ensures reasonable proximity of a doctor, hospital or nursing service in many areas.

Knowledge of legal restrictions on disposal of containers or pesticides was virtually absent and almost certainly, existence of the relevant laws would not have influenced disposal practice. Findings in the N.S.W. survey<sup>54</sup> on knowledge of more general aspects of the law regulating pesticides, were similar.

Knowledge of correct disposal methods among Tasmanian interviewees was generally poor, and the average scores were 25% and 39% for disposal of pesticides and containers respectively. Storage technique was similarly poor, the average assessment being 25%. Average score for knowledge of container disposal and storage was only marginally higher among those who had claimed to have been exposed to information than among those who had not.

#### 4.2.4 Behaviour

Practices in the treatment of poisoning, and of disposal and storage are activities central to this document. Treatment of poisoning left much to desire: in terms of equipping himself with appropriate medicaments, etc., only one farmer of the 100 interviewed had both atropine and Ipecac Syrup on hand, and only 59% of farmers had on hand one item which was recognized as useful in treatment of poisoning. Possession of both Ipecac Syrup and atropine, as well as label instructions, would allow successful treatment on the farm of the vast majority of poisoning cases. A total of more than 43 instances of poisoning were reported among the 100 interviewees, and they were divided between humans and animals in a ratio of approximately 1:2. In only a third of the human cases, some

of which were severe, was medical contact made. In the survey carried out by Nancarrow<sup>55</sup>, only one person (4%) had Ipecac Syrup on hand, and none had atropine.

In the context of disposal of pesticide and container wastes, 79% of farmers were aware of the existence of public tips in the area, and these were used by 46% of (all) farmers interviewed. The main reasons given for use of the tip (as opposed to farm disposal) were the greater ease, and the adequacy in relation to the farmer's requirements. Tip non-users criticised this practice on the grounds of residue build-up in a small area, and access to children, etc. Tip non-users overall seemed happier about the security of their own procedure (i.e., farm disposal). Use of the tip, as found in the N.S.W. survey<sup>56</sup>, was by 51% of farmers interviewed, and in the Nancarrow study<sup>57</sup>, 60% had used the tip at some stage for their pesticide or container wastes.

The reasons given by Tasmanian farmers for accumulating waste pesticide included deregistration of products (Tok E<sup>®</sup>/nitrofen, DDT), 'loss' in storage, and lack of knowledge on how to dispose. Reasons suggested by Little et al<sup>58</sup> for the U.S. are similar. Less than 50% of those who had accumulated wastes, had made any attempt to dispose of them, the remainder having retained wastes in storage. Disposal was most commonly effected by pouring tank-mix or concentrate onto the ground. The actual site of disposal seems mainly to be a function of the natural features of a farm and of expedience. Some of the worse examples of disposal sites included a creek running through the property, a dump right at the edge of a dam, and an old well. An average score of 25% was gained for disposal method.

Aspects of pesticide disposal were briefly examined in the N.S.W. survey<sup>59</sup>, but they are hard to relate to the Tasmanian survey. An exercise carried out by the Department of Agriculture in Western Australia<sup>60</sup> was a well publicised offer to accept for disposal waste pesticides and containers. From approximately 320 farmers, four responded. The principal reason for the poor response was thought to be largely a result of farmer indifference to the problem, but not of lacking wastes. Comment from government departments in Victoria suggests the existence of lax practice or attitudes towards handling in that State also<sup>61</sup>.



Unsatisfactory container disposal sites.



Practice of disposal of containers was assessed at an average score of 69% - much better than for pesticide. Public tips or pits on the farm were the destinations in 64% of cases for unburnt containers. The remaining 36% generally joined other rubbish or containers on heaps which were usually exposed to leaching by rain, and accessible to most mobile organisms. Container disposal was a two-step process: immediately or soon after emptying, the containers were put in a place of temporary residence for periods between a few days and "years" prior to final disposal. In 55% of cases interviewed, security of containers at this point was inadequate. For this reason, the attention seemingly given the final disposal act was partly misguided. One of the less desirable and not uncommon (16%) practices, was the disposal of containers within 10 m, and often less, of water or a watercourse.



High water table and domestic water channel (in the background). Almost all of these containers held pesticide.

The N.S.W. survey<sup>62</sup> showed that the percentage of farmers whose containers reach either the public tip or a pit on the farm was about 57%, similar to the 64% in Tasmania. In both cases, the tip was used more frequently than the farm dump. Some form of re-use of pesticide containers was found among 17% of farmers in the N.S.W. survey<sup>63</sup> - much better than the 55% in Tasmania.



Farm container disposal: temporary resting place -  
or permanent?



Some insight into the farmer disposal situation in the United States may be found in Little et al<sup>64</sup>, where some variations on Australian practice are found, most notably the returning of containers and pesticides to the distributor.

When interviewees were asked whether help with the disposal of pesticides and containers would be appropriate, 44% were in favour. The most common suggestion was instigation of a collection service. Commonly requested also was advice on disposal technique with a demonstration on the farm, as well as the installation of a well supervised and designed public disposal point near the farm.



Storage practice was rated at an average of 48% for Tasmanian interviewees. One of the most common shortcomings was inadequate security of storage. Nancarrow<sup>65</sup> reports that 44% of the farmers he surveyed stored their pesticides behind lock and key. This was much better than the 7% in Tasmania, but may possibly be explained by the greater chance of theft in the near-city area he surveyed.

#### 4.2.5 Magnitude of problem

Magnitude of the waste problem was difficult to assess for pesticides. Thirty-one (31%) interviewees claimed to have accumulated wastes at some



Storage that was less than satisfactory.





Average storage.

stage, in quantities varying from 200 litre to very small amounts. It is possible that these quantities had arisen over quite some time and in some cases, more than ten years. Disposal of tank-mix pesticide was rarely mentioned as a waste, but most likely, it is something which all farmers would have disposed of at some stage. Quantities of tank-mix would be very difficult to estimate, but their occurrence was probably grossly understated by interviewees. Extrapolated figures indicated that farmers would generate approximately 54,000 non-combustible containers annually; this was roughly half the number of combustible containers that would be generated. To this must be added the wastes of contractors, distributors, government bodies (such as the Forestry Commission), and home gardeners, to obtain a total-State figure. The only possible cross-check of this estimate came from an Agricultural and Veterinary Chemicals Association audit of liquid containers 'produced' by member companies in 1976 for the total Australian market<sup>66</sup>. If the total figure (of 2.6 million) is adjusted for Tasmania<sup>67</sup>, then the number generated in the State is approximately 90,000 annually. To compare this figure with that estimated from the survey required upward and downward adjustments to allow respectively for powder-form pesticide containers, and the proportion of combustible containers. There seemed, however, to be general agreement about the order of magnitude of the container number.

As mentioned above, the number of farms on which poisoning had occurred was 32, and the total number of instances of poisoning, in excess of 43. None could be linked to inadequate disposal or storage technique (although the meaning of 'storage' is open to interpretation).

#### 4.3 RESULTS OF FURTHER RESEARCH INTO THE TASMANIAN SITUATION

Whilst the survey of farmers was the main data-gathering exercise in this project, significant quantities of other relevant information were compiled, and these are reported here.

##### 4.3.1 Municipal tips

It was found that municipal tips were used by 46% of the interviewees for disposal of their pesticide and container wastes. Assuming the same

'production' rate of unburnable containers by tip-users and non-users, this means that 46% of the approximately 54,000 containers produced annually by farmers is destined for tips, i.e., approximately 25,000. Of the total of 126 licenced tips around the State, the locations of approximately 80 suggests that they would probably be used regularly by farmers, i.e., on the average each tip would receive approximately 350 containers per year. Whilst highly theoretical, it is useful as a guideline, to consider what these 350 containers may retain as residues. Using the data in Table 26, (Page 229 ), the calculation in Appendix XII shows that, on average, twelve litres of concentrated liquid pesticide would be transported annually to the 'average' tip in containers. This would be an understatement of the total quantity because it makes no allowance for dry powder pesticides, nor for containers generated by contract sprayers, home gardeners, government institutions and others. More importantly, it understates the likely volume in those containers, because the calculation is based on well-drained containers. On the other hand, no allowance is made for container rinsing, which is practised by about half of the farmers interviewed.

To this loading must be added a further quantity to allow for cases of pesticide dumping. In fact, any distinction between container disposal and pesticide disposal at a municipal tip would be entirely arbitrary, as the latter would normally be transported in its original container. The author suggests, therefore, that the 'average' municipal tip receives a total of approximately 15 to 25 litres of pesticide concentrate per year, generally in containers which may or may not be sealed.

Whilst carrying out the farmer survey, opportunities arose to inspect several municipal tips. Whilst control of access to tips was variable, it was generally easy, particularly for people (or animals) on foot. Sites were, however, usually well away from housing and areas likely to be frequented by children. Guidelines for development and selection of actual sites have been prepared by the Department of the Environment<sup>68</sup>, and the main considerations are the location of groundwater and the likelihood of leachate reaching it, availability of material to cover refuse, permeability of soil, and ultimate use of the area. Inspection of the 126 sites is carried out by more than ten inspectors across the State, and covering of refuse occurs at intervals varying from daily up



Two tips in the Huon Valley.





Access to some tips is easy.

to four months. Information on the frequency of covering for 75 of the 80 'rural' tips is summarized in the chart below:

Interval Between Coverings		No. of Tips	Interval Between Coverings		No. of Tips
1 day		4	2 - 4 weeks		4
1 - 2 days		1	1 month		12
2 - 3 days		1	1 - 4 months		1
3 - 4 days		1	2 months		8
1 week		11	2 - 4 months		2
1 - 2 weeks		1	3 months		28
			4 months		1

Table 9 : Frequency of covering of municipal tips<sup>69</sup>.

From the table, it can be seen that 69% of tips are covered at intervals of a month or more, 52% at intervals of two months or more, and 39% at intervals of three months or more. Periods of ready access to these wastes may therefore be appreciable.



Note the high water table or poor drainage and the drain (lower picture, middle left) emptying into free water beyond.

There seems to be no question that such use of municipal tips is legal. Under the Environment Protection (Waste Disposal) Regulations<sup>70</sup>, waste pesticides and pesticide containers are classified into Schedule I, Environmentally Dangerous Wastes. Section 5 of these Regulations states -

*No person shall dispose of, or cause, or knowingly permit to be deposited at any place any environmentally dangerous waste, except in accordance with a method approved by the Director.*

The method approved by the Director is that which was published in the Tasmanian Journal of Agriculture<sup>71</sup>, and although these instructions are intended primarily for farm disposal, they apply also to disposal on tips.

In the general context of municipal tips, it is of interest to know that the Department of the Environment supervises analysis of the leachates from at least three tips in the State. The exact whereabouts of these tips could not be determined, but the author believes them to be urban rather than rural. This may explain the negative analyses obtained to date<sup>72</sup>. By contrast, analyses of leachate from a Sydney suburban tip showed small quantities of pesticide which had probably come from discarded containers. Occurrence of the same compounds further downstream in a watercourse suggested a chronic low-level contamination of the stream, which in the case of bio-accumulating pesticides, could have undesirable effects<sup>73</sup>.

Whilst tips are not likely to be the only source of contamination of groundwater in Tasmania, they would probably be important contributors. In fact, little is known of the purity of Tasmanian groundwater, but in general the sandy coastal areas are believed to be more prone to contamination<sup>74</sup>.

#### 4.3.2 Product withdrawals

In recent years, two pesticide products have been withdrawn from the general market - DDT and Tok E<sup>®</sup>/nitrofen.

DDT was finally withdrawn from sale in Tasmania in 1978 as a result of recurring residue problems in export-grade cheese. The Division of Public Health was responsible for the decision, and its execution was a joint operation with the Department of Agriculture. 'Disposal' was achieved largely by a phased withdrawal and relocation of stocks out of dairying areas<sup>75</sup>.

Withdrawal of Tok E<sup>®</sup> was instigated and executed by the manufacturer at the request of Australian health and regulatory authorities. Distributors were advised of the decision, and return of stocks to the manufacturer was requested. Disposal of this product was not necessary because it was possible to export to New Zealand, where registration still stood<sup>76</sup>.

#### 4.3.3 Instances of unusually large disposals in Tasmania of pesticides or containers

In recent years, there have been at least two verifiable instances of disposal in Tasmania of relatively large quantities of pesticide. In one case, a contract sprayer was faced with appreciable (unknown) quantities of mixed liquid pesticide concentrate. Disposal was effected under close supervision of the Department of the Environment at a municipal tip. At the time, particular attention was paid to soil permeability, surrounding vegetation, the depth of cover, and location in the tip in relation to other activities<sup>77</sup>. On the other occasion, a government department had in its possession 60 L of sub-standard herbicide, and 20 L and 20 kg of two other herbicides which had become obsolescent due to changed application methods. These wastes were disposed of into a disused mineshaft in a plantation<sup>78</sup>.

Some of the State's spray contractors were spoken to, and their containers were generally put in the local tip - with council knowledge.

#### 4.3.4 Education and publicity about pesticide disposal

The public release of pesticide disposal instructions by the Agricultural and Veterinary Chemicals Association throughout Australia in 1971<sup>79</sup> was accompanied by an official press release. However, actual coverage in newspapers was less than expected<sup>80</sup>, and as far as could be determined, this release received no coverage in Tasmania. However, in 1974,



specific publicity was given to gazetting of the regulations under the Environment Protection Act which referred to pesticide and container disposal<sup>81</sup>.

Beyond the release of the wall chart mentioned above, there has been a low-intensity campaign on safety of pesticide use and handling by most and perhaps all of the 13 District Extension Officers in the Tasmanian Department of Agriculture<sup>82</sup>. In general, this campaign takes the form of brief reminders of important aspects of pesticide use and handling via such channels as the District Newsletters, or field days, or on the occasion of farm visits. There seems general agreement among District Extension Officers that, for two main reasons, heavy campaigns on pesticide safety are unlikely to succeed. Firstly, because the farmer does not seem to place safety of pesticide handling high among his priorities of interests or concerns, his attention to any such campaign would be minimal. Secondly, because the farmer sees no monetary return for greater safety in pesticide handling, he is unlikely to spend time at meetings or demonstrations which cover only aspects of safety<sup>83</sup>.

It is interesting to relate these statements and attitudes of officers in the Tasmanian Department of Agriculture to the findings of a campaign on "safe, responsible, pesticide use" conducted by the Department of Agriculture in New South Wales. This campaign came in the wake of major changes in the State's Pesticide Act, and was intended to create among farmers a functional awareness of these changes. A number of communication channels was used, varying from television, radio and newspapers, through direct mailings, distributor displays, and field days to competitions, word-of-mouth, etc. A preliminary assessment, on the basis of telephone interviewees before and after the campaign, was that the exercise had been very successful<sup>84</sup>. The campaign and its slogan, "Look alive! It's all on the label" were based partly on ideas which had proven successful in the United States<sup>85</sup>.

In this general context, it is interesting to note one correlation which emerged from the Tasmanian survey - namely, knowledge of container disposal method was significantly correlated with practice of disposal. (Correlations between knowledge of pesticide disposal method and its

practice were not assessed, and no correlation was found between knowledge of storage method and its practice.) Pesticide safety campaigns in the United States sometimes employ a fear (tension-reducing) motivation as a means of obtaining results, i.e., the possibility of harm befalling 'loved ones' or valued objects such as commercial stock as a result of inadequate practices<sup>86</sup>. The Tasmanian survey found no significant difference of behaviour between those having (all four of) children, pets, working dogs and livestock, and those who had three or fewer of these.

#### 4.3.5 Recycling of pesticide containers

Recycling of pesticide containers is established practice in the United States, and there is no immediately obvious reason why this should not be possible in Australia, particularly where 200 L drums are involved. In fact, a small amount of recycling of 200 L drums occurs in Melbourne<sup>87</sup> but, there is none in Tasmania<sup>88</sup>. Through the Agricultural and Veterinary Chemicals Association, the industry has considered the possibility of container recycling in certain areas, but found it uneconomical<sup>89</sup>.

#### 4.4 INTEGRATION AND DISCUSSION

This project set out to answer three main questions: how does the farmer dispose of waste pesticides and containers, why does he do it in such a way, and what are the consequences of these methods? In this section, these questions are answered, and the chapter is concluded with a consideration of action which could be taken.

##### 4.4.1 Disposal and storage practices and their consequences

Thirty-one of the 100 farmers interviewed had, at some stage, accumulated or disposed of waste pesticide. Only five of these had used either a tip or a suitable site on the farm, and that fact should be viewed with some disquiet. The remainder had disposed of waste pesticides, both tankmix and concentrates, onto the ground on or near the farm, into existing holes or hollows on the farm, or into such things as an old well, or a stream passing through the property. The actual consequences of these practices are difficult to assess with any accuracy, but in general, only soil microbes and plants would be harmed in small areas. In no case was

there evidence that disposal practices had led to serious damage, and in the worst examples encountered, some harm to aquatic organisms may have resulted, but probably little more. However, whilst such practices generally cause little, if any, significant injury, they fail to take into account any *potential* risks. In a number of instances, the farmer could have been sure about only one thing: namely, that the pesticide being disposed of would be diluted to some degree. The ultimate fate and actions of the pesticide discarded, for example, into the creek, the dam, the well, sink holes, burrows or compost would remain largely unknown, and could extend to humans or livestock. Even in the few cases of acceptable disposal, a small possibility of creating a source of chronic low-level contamination exists, and this has potential for greater harm particularly where the pesticide has a tendency for bio-accumulation. Perhaps the most serious actual and potential situation exists where waste pesticides have not been disposed of. In a number of such cases, the waste products were of the older, more toxic type, and the containers were close to disintegration, or had actually disintegrated. Whilst more than 70% of interviewed farmers stored their pesticides more than 20 metres from the home, such stored wastes or their spilled remains represent a real hazard to children, working dogs, etc. Often the structure of buildings housing pesticides was such that spills would be difficult or near impossible to clean up adequately, with the result that working areas would remain contaminated for some time.

Disposal of containers was carried out more satisfactorily than disposal of pesticides, although this was due partly to acceptance and high scoring in the assessment of tip disposal. In 98% of assessed cases, a positive attempt to dispose of containers had been made. Local tips received the containers from 42% of farmers interviewed, and a further 22% put them in pits on the farm. The remainder finished on a general rubbish tip on the farm, and in the majority of cases these would have been subject to the leaching effects of rain, puddling or running water. The container disposal process was generally marked by a stop-over point between (and sometimes at) the point where the container's contents had been used, and the site of final disposal. Residence at this intermediate site sometimes lasted years, and in 55% of cases was unsatisfactory because containers were unduly accessible, or had not been rinsed. The potential consequences

of these practices were generally similar in nature to those mentioned in the preceding paragraph, but of a lower grade. On the other hand, because disposal of containers should be carried out by nearly all farmers, the frequency of occurrence of potentially hazardous situations would be much greater than for pesticide disposal. Again, there was no evidence to suggest that harm arising from poor disposal technique had extended to humans, pets, livestock, etc., and where containers were disposed of into a hole, little more than localized effects on soil microbes and perhaps plants would be expected. Dumping at public tips introduces a quantity of concentrated and dilute pesticide to a relatively small area, but it would be expected that release of this pesticide from containers would be spread over a period of time. Leaching from a tip would most likely occur, but concentration of the pesticide would probably be very low, and any damage, localized. During the interval between coverings at tips (two months or more for 52% of rural tips), there is a definite potential for poisoning of children, dogs, wildlife, etc. (as well as of vermin). Disposal at tips was rated higher in the survey than careless farm disposal, but the duration of free access to containers at public sites, combined with the fact that tip disposal seemed not to follow guidelines issued by the Department of the Environment, render tips not entirely satisfactory disposal points. The proportion of farmers (16%) who disposed of containers on the farm within 10 m of water is disturbing, because of the potential to produce occasional short-term high-concentration contamination of smaller streams. The two-stage pattern of container disposal, because it results in accumulations of containers around working areas and the home, does increase potential for mishap.

Storage practices fell down mainly in the area of security from children, wildlife, etc., and again, whilst no evidence of injury arising directly from inadequate storage was encountered, ready access represents unnecessary potential risk.

The comments above apply to a random sample of 100 farmers across Tasmania, and it would therefore be expected that findings are indicative of practices, consequences, knowledge, etc., for the whole State. Overall, it can be seen that consequences of generally inadequate farmer practices are mainly localized, and in general any noticeable effect would be restricted to

the property where disposal had taken place. However, because it is probable that these practices are prevalent across the State, the possibility of chronic low-concentration dispersal of pesticide from a number of disposal sites does exist. Furthermore, in a world which is more and more subject to pollution of different types, any further unnecessary addition to background low-grade pollution should and can easily be avoided.

#### 4.4.2 Reasons for existing disposal and storage practice

Farmers' knowledge, attitudes, exposure to information and opinion influencers were assessed in an attempt to identify factors which underlie their practices.

Specific knowledge of correct techniques of pesticide storage and disposal was, on average, poor, and of container disposal, not much better. It has been shown that for all three activities, readily accessible information does exist. However, in the cases of both pesticide and container disposal, it seems unlikely that many farmers would have seen this, but if they had, it was some time ago. This fact largely explains the poor specific knowledge of disposal, but it must not be overlooked that a good working general knowledge of pesticides could largely compensate for any lack of specific knowledge. Because adequate information on pesticide storage is generally found on package labels, a better level of knowledge (than for disposal) could have been expected. In fact, this greater accessibility did not improve knowledge beyond the level shown for correct pesticide disposal methods. Recalling that the bases of the assessments of knowledge and of practice were almost identical, it is curious that practice was as good as, or better than knowledge for all three activities. This suggests operation of general working knowledge of pesticides, or of sub-conscious factors. It may also indicate that the assessment was not valid.

The assessment of the farmers' general knowledge of the harmful effects of pesticides showed that, overall, 25% of farmers did not associate harmful effects with the correct use of pesticides. However, the average score of 56% in the more detailed assessment of knowledge in this area, suggested an appreciable awareness of potential hazards. This was not generally reflected in the practices assessed, nor would the farmers' nearly complete lack of knowledge of legal regulation have influenced his practices.

The survey of farmers' attitudes showed some general reservations about the use of pesticides, but it also suggested that farmers see pesticides as an essential tool for successful farming. This latter belief is instructive, if viewed in the context of three other points. Firstly, a poll of farmers across Australia confirmed the belief that pesticides are essential. Secondly, another survey of farmers in south-eastern Australia showed 'family security' to be the highest priority goal among farmers, and thirdly, officers of the Tasmanian Department of Agriculture expressed the opinion that farmers accord low priority of attention to activities which have no financial return. Taken together, these findings about the attitudes of farmers suggest that pesticides are seen primarily as tools for making money, and that any other properties they may have, are very subordinate.

In the light of the comments above, it seems more appropriate to consider farmers' knowledge and practice in the areas of poisoning by pesticide as a further expression of attitudes. Overall, the farmers' ability to recognize and treat adequately cases of poisoning by pesticide is poor. Whilst it may be argued that the farmer may rationalize his (perceived) pesticide handling ability against his preparedness for an actual poisoning, it seems more likely that he gives little productive thought to the dangers of pesticides (although it is also possible that his self-perceptions are somewhat awry).

Finally, it should be mentioned that an awareness among farmers of anti-pesticide views in the community was found. However, what influence these views have on practices was not determined.

It is evident from comments above that the generally poor practices observed among farmers may be partly explained by lack of exposure to appropriate information and consequent poor knowledge, and by the fact that the farmer gains little in the achievement of his basic goals by adopting good pesticide handling practice. This latter point was manifested not only in the lack of interest in obtaining information, but also in the high frequency of occurrence of expedient disposal of pesticides and containers. (In the case of containers, whilst disposal at a municipal tip is sound practice in principle, it was clear that there was also an expedience

motivation.) The apparent lack of any fear motivation towards good practice, accorded with actual behaviour.

These various findings are taken up in the following section.

#### 4.4.3 Future action

Present disposal and storage practices are largely unsatisfactory, and whilst the undesirable consequences are generally limited, some action should be taken to minimize these effects. Any decision on further action requires further detailed study, but comments below provide some orientation.

Two important findings of this project have been, firstly, the inadequate exposure of farmers to information appropriate to acquisition of knowledge of correct practice; and secondly - if farmers' generally low motivation in areas of pesticide safety is accepted as largely unchangeable fact - the need for development of, or education about expedient disposal and storage methods. In relation to communication, it is clear that the Department of Agriculture enjoys credibility among farmers and also uses channels of communication which reach the farmer. It is logical that the Department of Agriculture should be responsible for increasing exposure of the farmer to such information, and a report on the recent campaign conducted by the Department of Agriculture in New South Wales on safety in pesticide handling, contains useful guidelines for a similar programme in Tasmania<sup>90</sup>.

As already mentioned, there are a number of probable reasons why present disposal and storage practices do not conform with recommended methods, and one of them is a need for greater expedience. There are two possible approaches to this problem: make recommendations for easier methods of disposal, or, give an undertaking to assist the farmer.

- a. A number of farm-oriented disposal methods is outlined in Chapter 3 and among them is disposal onto concrete under certain conditions (see Page 54), or onto ground in a suitably level and remote area (see Page 51). A further method receiving current attention is disposal into cattle manure (see Page 50), and this may prove a

useful direction of investigation, particularly if the manure of other species such as sheep and pigs, or composts of vegetable material such as reject or waste silage or hay, proved capable of supporting microbial degradation. Incorporation of specific bacterial cultures into such media could also be considered. It is also possible that chemical methods of degradation may be perceived by the farmer as simpler than current recommendations. But it is also recognized that there are advantages in making only a small number of recommendations, and if possible, only one which is suitable for all compounds and farm situations.

- b. Assistance may also be rendered the farmer in the form of advice, covering such things as the most desirable disposal method for a given product, or in the form of waste pesticide receiving services. In this case, 'offerings' from annual, well publicized collection campaigns could be disposed at treatment sites located, for example, at Research Stations of the Department of Agriculture. The work being carried out by Hall et al (see Page 49) on microbial pits would have great relevance in any such plan. Because of the relatively small quantities involved, research into disposal through existing sewage trickle filters could be fruitful, and would represent a cheap method of disposal. Finally, industrial incineration facilities, if ever set up in the State for industrial wastes, would offer another avenue for disposal of collected wastes.

The economics of a container collection service would need investigation, but 'self-serve' collection vehicles left at advertised points for a week at a time may solve this problem. Such a service should be able to ensure rapid and effective burial of containers deposited at a tip. Community-organized projects could also provide a cheap answer to this problem, and also offer the same safety of disposal at tips.



## NOTES

1. As part of the whole project, the author wrote to a number of rural newspapers (see Appendix I, 1.4). No indication of public concern about this practice was reported, although the Huon News had given coverage to some public complaint over a municipal tip situated right on the Huon River.
2. NANCARROW, R. J., 1977; Practices and precautions with pesticides - a study of knowledge and behaviour of growers towards pesticides; (30pp., 5 refs.). Project submitted as part of the requirements for Diploma of Agriculture Extension, University of Melbourne, Australia. This was a small study of 25 vegetable growers in the outer eastern suburbs of Melbourne.
3. LENNE, B. D., Department of Agriculture, New South Wales, 1981; Personal communication. This study, contracted by the N.S.W. Department of Agriculture, was part of a survey aimed at monitoring the success of an extension programme based on changes to the State's Pesticide Act. The changes instigated impinged quite significantly on farmer practices. Information received related to the period before the education campaign.
4. DIGBY, G. J. A., Agricultural and Veterinary Chemicals Association, Sydney, 1980; Personal communication. This study related only to containers generated by domestic and home garden use.
5. See the following:
  - a. LEONARD, J. G., 1977; Hydrogeology and hydrochemistry of the Lucas Heights waste disposal site, and extent of leachate transport in tributaries of George's River; Project report for Master of Applied Science, University of New South Wales, Australia.
  - b. KNIGHT, M. J., J. G. LEONARD and R. J. WHITELEY, 1978; Lucas Heights solid waste landfill and downstream leachate transport - a case study in environmental geology, Bulletin of the International Association of Engineering Geology 18, 45-64.

6. LEWIN, K., 1967; Field theory in social sciences; Social Science Paperbacks, as cited in: ROWEN, J., 1973; The science of you, p.67; Trinity Press, London, U.K.
7. LENNE, B. D., 1981; as Note 3. Because the results of the education campaign in New South Wales are being closely monitored, it seems possible that a study of the effects of law on pesticide handling may eventuate.
8. NANCARROW, R. J. 1977; as Note 2.
9. LENNE, B. D., 1981; as Note 3.
10. See, for example, ROGERS, E. M. 1962; Diffusion of Innovations; Free Press of Glencoe, Macmillan Company, New York, U.S.A.
11. LENNE, B. D., 1981; as Note 3.
12. NANCARROW, R. J. 1977; as Note 2.
13. LENNE, B. D., 1981; as Note 3.
14. CRIBB, J., 'National Farmer', 1981; Personal communication. 'National Farmer' (Australian Farm Publications, Canberra) conducts a poll of farmers each year. The sample is that part of the newspaper's readership which bothers to reply. The numbers in this poll were  $900 \pm 5$  nation wide, and 29 in Tasmania.
15. ROWAN, J., 1973; The science of you, p.151; Trinity Press, London, U.K.
16. As above.
17. ROKEACH, M., 1973; The nature of human values; Free Press, New York, U.S.A., as cited in: HAWKINS, H. S., E. F. ALMOND and M. G. DWYER, 1974; Post-secondary educational needs of Australian farmers - a survey of opinions of farmers and agricultural college staff; University of Melbourne, Australia.
18. HAWKINS, H. S., E. F. ALMOND and M. G. DWYER, 1974; Post-secondary educational needs of Australian farmers - a survey of opinions of farmers and agricultural college staff; University of Melbourne, Australia.

19. ROGERS, E. M., 1962; As Note 10.
20. PRESSER, H. A., School of Agriculture and Forestry, University of Melbourne, 1982; Personal communication.
21. ROWAN, J., 1973; as Note 15, pp.64-83.
22. Only two others, both from the U.S.A., could be found:
  - a. LITTLE, ARTHUR D., INC., 1977; Economic analysis of pesticide disposal methods. Strategic Studies Unit, U.S. Environment Protection Agency, Washington D.C. EPA 540/9-77-018.
  - b. RYAN, S. O., 1974; A study of pesticide use, storage and disposal in Iowa, Ph.D. dissertation, Iowa State University, Ames, Iowa, U.S.A.
23. NANCARROW, R. J. 1977; as Note 2.
24. LENNE, B. D. 1981; as Note 3.
25. NANCARROW, R. J., 1977; as Note 2.
26. LENNE, B. D., 1981; as Note 3.
27. See, for example,
  - a. ANON., 1980; Recommendations for the chemical control of weeds in pome and stone fruit (wall chart); Department of Agriculture, Tasmania, Australia.
  - b. ANON., undated; Pesticides Act, 1968; Government Printer, Tasmania, Australia. Wall chart outlining in detail precautions to be taken with pesticides.
28. NANCARROW, R. J. 1977; as Note 2.
29. LENNE, B. D. 1981; as Note 3.
30. CRIBB, J., 1981; as Note 14.
31. DEPARTMENT OF THE ENVIRONMENT, 1975; Approved method of disposal of pesticide and pesticide containers, Tasmanian Journal of Agriculture 46, 81-85.

32. ANON., 1971; Disposal of containers and unwanted pesticides, (wall chart); Agricultural and Veterinary Chemicals Association, Sydney. Approximately 2000 would have reached Tasmania but would not necessarily have reached the farmer.
33. O'LOUGHLIN, M., January 1978; Disposal of spray containers, Huon District Agricultural Newsletter, Department of Agriculture, Huonville, Tasmania. This was a reprinted story from 1976.
34. LENNE, B. D., 1981; as Note 3.
35. LENNE, B. D., 1981; as Note 3.
36. HAWKINS, H. S., et al, 1974; as Note 18.
37. Terminal values are beliefs relating to end states of existence. See HAWKINS, H. S., et al, 1974; as Note 18.
38. Instrumental values are single benefits expressing personal and social preferences for certain modes of conduct. See HAWKINS, H. S., et al, 1974; as Note 18.
39. LENNE, B. D., 1981; as Note 3.
40. CRIBB, J., 1981; as Note 14.
41. LENNE, B. D., 1981; as Note 3.
42. CRIBB, J., 1981; as Note 14.
43. CRIBB, J., 1981; as above.
44. CRIBB, J., 1981; as above.
45. CRIBB, J., 1981; as above.
46. CRIBB, J., 1981; as above.

47. See the following:

- a. BEAL, G. M., J. M. BOHLEN and G. LINGREN, 1966; Behaviour studies related to pesticides - agricultural chemicals and Iowa Farmers. Special Report No. 49, Agricultural and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, Ames, Iowa, U.S.A.
- b. BEAL, G. M., J. M. BOHLEN and W. A. FLEISCHMAN, 1979(?); Behaviour studies related to pesticides - agricultural chemicals and agricultural chemical dealers. Agricultural and Home Economics Experimental Station, Cooperative Extension Service, Iowa State University, Ames, Iowa, U.S.A.

48. LENNE, B. D., 1981; as Note 3.

49. NANCARROW, R. J., 1977; as Note 2.

50. MOULDS, R., Department of Agriculture, South Australia, 1981; Personal communication.

51. NANCARROW, R. J., 1977; as Note 2.

52. NANCARROW, R. J., 1977; as above.

53. LENNE, B. D., 1981; as Note 3.

54. LENNE, B. D., 1981; as Note 3.

55. NANCARROW, R. J., 1977; as Note 2.

56. LENNE, B. D., 1981; as Note 3.

57. NANCARROW, R. J. 1977; as Note 2.

58. LITTLE, ARTHUR D., INC., 1977; as Note 22a.

59. LENNE, B. D., 1981; as Note 3.

60. GABBEDY, B. J., Department of Agriculture, Western Australia, 1981; Personal communication.

61. a. MATTHEWS, D., Department of Agriculture, Victoria, 1981; Personal communication.

b. MILES, T. W., State Rivers and Water Supply Commission, Victoria, 1980; Personal communication.

62. LENNE, B. D., 1981; as Note 3.

63. LENNE, B. D., 1981; as above.
64. LITTLE, ARTHUR D., INC., 1977; as Note 22a.
65. NANCARROW, R. J., 1977; as Note 2.
66. DIGBY, G. J. A., 1980; as Note 4.
67. The conversion was carried out using data in, ANON., 1981; Agricultural establishments operated by agricultural and non-agricultural enterprises by industry of establishment, in: Agricultural sector Australia, Structure of operating units; Australian Bureau of Statistics, Canberra, Australia.
68. ANON., undated; Municipal refuse disposal (roneoed notes for issue to seekers or holders of a licence for a disposal site); Department of the Environment, Tasmania, Australia.
69. BOURKE, W., Department of the Environment, Tasmania, 1981; Personal communication.
70. See Statutory Rules 1974, No. 225: Environment Protection (Waste Disposal) Amendment Regulations 1974, Section 2, gazetted 25 September 1974.
71. DEPARTMENT OF THE ENVIRONMENT, 1975; as Note 31.
72. POTTINGER, J. F., Department of the Environment, Tasmania, 1981; Personal communication.
73. LEONARD, J. G., et al, 1977/8; as Notes 5a, 5b, 5c.
74. CROMER, W. C., Department of Mines, Tasmania, 1981; Personal communication.
75. McARDLE, E. J., Division of Public Health, Tasmania, 1981; Personal communication.
76. BLYTH, R. H., Rohm and Haas Australia Pty. Ltd., Melbourne, 1981; Personal communication.
77. HEALEY, B. O., Department of the Environment, Tasmania, 1981; Personal communication.
78. WITTE, L. H. P., Forestry Commission, Tasmania, 1982; Personal communication.

79. ANON., 1971; Disposal of containers and unwanted pesticides (wall chart); Agricultural and Veterinary Chemicals Association, Sydney, Australia.
80. DIGBY, G. J. A., Agricultural and Veterinary Chemicals Association, Sydney, 1980; Personal communication.
81. ANON., 25 September 1974; Hard line on waste; Mercury, Hobart, Tasmania.
82. As part of the survey, all District Extension Officers were spoken to about prevalent practices with pesticides in their District, as well as any efforts made in the District to improve pesticide handling.
83. Personal communication with District Extension Officers of the Department of Agriculture.
84. LENNE, B. D., 1981; as Note 3.
85. See the following:
  - a. SALCEDO, R. N., H. READ, J. F. EVANS and A. C. KONG, 1971; Improving the communication adequacy of pesticide labels: Phase I summary report; Agricultural Communications Research Report 25; Office of Agricultural Communications, College of Agriculture, University of Illinois at Urbana-Champaign, U.S.A.
  - b. SALCEDO, R. N., H. READ, J. F. EVANS and A. C. KONG, 1974; Effects of an information campaign about safe use of pesticides, Agricultural Communications Research Report 27; Office of Agricultural Communications, College of Agriculture, University of Illinois at Urbana-Champaign, U.S.A.
  - c. SALCEDO, R. N., H. READ, J. F. EVANS and A. C. KONG, 1973; Improving user attitude toward and readership of pesticide labels: a summary report; Agricultural Communications Research Report 26; Office of Agricultural Communications, College of Agriculture, University of Illinois at Urbana-Champaign, U.S.A.
86. SALCEDO, R. N., et al, 1973; as Note 85c, p.4.

87. COOPER, T., Melbourne Drum Services, Melbourne, 1982; Personal communication.
88. GREEN, J., I.C.I. Australia Operations Pty. Ltd., 1980; Personal communication.
89. DIGBY, G. J. A., Agricultural and Veterinary Chemicals Association, Sydney, 1981; Personal communication.
90. LENNE, B. D. and C. C. BLACK, 1981; Planning, implementation and evaluating the New South Wales mass media campaign: Safe, responsible pesticide use; Melbourne Notes on Agricultural Extension, No. 17, University of Melbourne, Australia.



CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

- a. A number of methods for disposal of waste pesticides on the farm by the farmer exists. Among these is one which has been designed to meet the needs and circumstances of the Australian farmer. In basic concept this method is sound, but attention to some of the details is required. It is also possible that other equally effective methods may find better acceptance among farmers.
- b. There exist other methods of disposal of pesticides which, because of their cost and capacity, are more suited to community use. There may be application in Tasmania for these methods.
- c. Because of the relative simplicity of the methods of container disposal and pesticide storage, there tends to be little variation in the techniques approved by different bodies.
- d. Knowledge of correct disposal and storage among 100 randomly selected farmers was poor, and practice of these aspects of pesticide handling was generally inadequate. Knowledge and practice of this sample would be indicative of knowledge and practice among Tasmanian farmers in general.
- e. Ability to recognize poisoning by pesticides, and knowledge and practice of treatment of poisoning among a random sample of 100 farmers was poor. Furthermore, in terms of preparedness for treatment of cases of poisoning, items possessed or recognized by farmers in the sample as useful in poisoning cases, were few. Nevertheless, the proximity and ready availability of medical aid, and to a lesser extent, of veterinary aid, is probably adequate for successful treatment in most cases of poisoning.

- f. The reasons for poor knowledge and practice of pesticide and container disposal are the relatively low exposure of the farmer to appropriate information, and attitudes which confer low priority of treatment on such activities.
- g. The actual consequences of presently used methods of disposal and storage do not appear to be serious, but localized, transient, low-grade contamination would often result. The potential dangers arising from these practices are somewhat greater in significance, and commonly the farmer does little to minimize these risks.
- h. Use of municipal tips as a point of final disposal of pesticide containers was preferred by 42 per cent of farmers. Whilst this practice removes potential hazards from the farm, frequently the management practices at tips do not reduce all of these potential hazards for some time, if at all.
- i. The Tasmanian Department of Agriculture is a major source of information for the farmer including information on pesticides. This agency is the obvious choice for execution of any campaign aimed at safety aspects of pesticide handling. In certain areas, the advice and assistance of the Department of the Environment and the Division of Health should be sought.

## 5.2 RECOMMENDATIONS

- a. Steps should be taken to improve farmers' practice of pesticide and container disposal and storage. This would best be done in the framework of a continuing programme aimed at all aspects of safety in the use and handling of pesticides. Further research into other aspects of safety in use and handling of pesticides should be undertaken prior to such a campaign.
- b. Steps should be taken to reduce the potential hazards arising from disposal of containers at municipal tips.
- c. Research in Australia on the effectiveness and applicability in Tasmania of certain biological disposal methods suitable for both farmer and community should be instigated. Some consideration should also be given to refinement of the existing Australian recommendations for pesticide disposal.

- d. Cost/benefit studies of farm disposal of containers and pesticide compared with centralized disposal should be undertaken. Any consideration of centralized facilities for disposal of pesticide must take account of all sources of wastes, and not only farmers'.

## APPENDICES

## APPENDIX I

### Australasian Sources of Information on Pesticide Storage and Disposal

Because of the difficulty in obtaining information from a diversity of sources, it seems worthwhile to outline local sources of information. Secondly, because it seems that very little work of any type has been done on pesticide disposal in Australia, a brief review of the situation could be useful for any parties interested in the future.

In seeking information in Australasia on any type of research or general activity in the field of pesticide disposal (behavioural, technological, environmental, etc.), an extensive correspondence was undertaken. The various organizations mentioned below were contacted by way of a general and open-ended exploratory letter. Whilst other groups could have been contacted, it seemed likely that this primary coverage would reveal any other areas of activity. Suggested points of further contact recommended by primary contacts, where not already contacted, are generally mentioned in the body of the text or the bibliography. Whilst the response to the initial enquiry was generally one of interest and the assistance rendered was much appreciated, the number of leads to new sources of information not already known, was small.

#### 1.1 Universities

Overall response, whilst showing some interest, was usually very general and not particularly helpful.

##### 1.1.1 Departments/Faculties/Schools of Social Studies/Social Sciences or equivalent

[Australian National University (two departments), Flinders University, Griffith University, James Cook University, La Trobe University, Macquarie University, Monash University, Murdoch University, University of Newcastle, University of New England, University of New South Wales, University of Queensland, University of Wollongong.] Total information elicited from these departments was very small and restricted largely to further leads. One reply gave information on adoption of techniques among farmers

1.1.2 Departments/Schools/Faculties of Agriculture or the equivalent

[University of Adelaide, Australian National University - Research School of Biological Sciences, La Trobe University, Murdoch University - School of Environmental and Life Sciences, University of New England, University of New South Wales, University of Queensland, University of Sydney, University of Western Australia, University of Melbourne.] Responses ranged from "not generally regarded as a problem of national importance"<sup>1</sup>, to leads to other organizations and vaguely related work on pesticides. One survey<sup>2</sup> had investigated use and safety awareness towards pesticides among farmers, including a little about disposal.

1.1.3 Centres for Environmental Studies or the equivalent

[University of Adelaide, Australian National University, University of Canterbury (N.Z.), Griffith University, Macquarie University, University of Melbourne, Monash University, University of New England.] Again, response generally took the form of further leads to other bodies, but in one case a very general study on pesticides was discovered<sup>3</sup>.

1.2 Government organizations

Overall, Government organizations were far more helpful than universities. In most cases, however, information received was very general. Specific information on aspects of disposal, which were more than general impressions and which originated from the particular organization, came from only seven sources. Whilst valuable, this information was rarely extensive.

1.2.1 Federal bodies

Pesticides Section, Department of Primary Industry (the Federal registration body), provided information on correct disposal and storage methods for Australia<sup>4</sup> (which have been widely promulgated in various written forms). Valuable background information and comments on the project itself were also forthcoming. National Health and Medical Research Council provided a small amount of background information. CSIRO published a code of safe practice with pesticides, including information on disposal and storage<sup>5</sup>. Department of Home Affairs and Environment was the only other Federal Department contacted.

1.2.2 State bodies

- a. *New South Wales:* [Department of Agriculture, Metropolitan Waste Disposal Authority, Biological and Chemical Research Institute, Metropolitan Water, Sewerage and Drainage Board, State Pollution Control Commission, Water Resources Commission and Health Commission.] New South Wales proved an unusually fruitful area of enquiry due largely to two recent surveys, one on environmental damage arising from pesticide use<sup>6</sup>, and the other on farmer attitudes and practices with pesticides<sup>7</sup>.
- b. *Queensland:* [Department of Primary Industry, Water Resources Commission, Local Government Department, Water Quality Council.] Information forthcoming was fairly general, but did refer briefly to publicity on disposal problems.
- c. *South Australia:* [Department of Agriculture, Department for the Environment, Minister for Water Resources.] Some general information was obtained.
- d. *Tasmania:* [Department of Agriculture, Division of Public Health, Department of the Environment.] Over a period of time much valuable information was obtained including Tasmanian instructions on correct disposal technique<sup>8</sup>.
- e. *Victoria:* [Department of Agriculture, Ministry for Conservation - Environment Protection Authority, State Rivers and Water Supply Commission, Department of Crown Lands and Survey - Division of Inspection of Vermin and Noxious Weeds Destruction.] Brief comments on general impressions of farmer practices were received, and literature on correct practice<sup>9</sup>.
- f. *Western Australia:* [Department of Agriculture, Department of Conservation and Environment, Waterways Commission, Metropolitan Water Supply, Sewerage and Drainage.] Information was obtained on incineration of hazardous chemicals, and on a small pesticide and container 'clean-up' campaign.
- g. *New Zealand:* [Ministry of Agriculture and Fisheries.] General comments only were forthcoming.

### 1.3 The Agrochemical Industry

The agrochemical industry is represented federally by the Ageicultural and Veterinary Chemicals Association (AVCA). AVCA and 29 member companies (only one of which is not the subsidiary of an overseas principal) were contacted. AVCA provided valuable background information, particularly on the distribution of charts for farmers which relate to differenc aspects of pesticide safety<sup>10</sup>. Individual companies gave information specifically on disposal in only four cases.

### 1.4 Newspapers

It was hoped that newspapers may have stories of irresponsible disposal or general farmer practice with pesticides. The Mercury, Examiner, North East Advertiser, Huon News, Advocate, Circular Head Chronicle, Tasmanian Mail, Tasmanian Country, National Farmer, Weekly Times produced no specific 'stories' on disposal, but the results of a national opinion survey on pesticides was discovered<sup>11</sup>.

### 1.5 Miscellaneous

Standards Association of Australia produces a code of safe pesticide handling<sup>12</sup>.

Subsequent to this initial exploratory letter, four further Government documents on waste disposal have been published, but none gives great prominence to pesticide wastes in either industrial or farm situations<sup>13</sup>.

Approximately 15 further general exploratory letters were sent to European and American universities, institutions and government departments. These contacts were very fruitful overall.

- 
1. HILL, M. K., University of New England, New South Wales, 1981; Personal communication.
  2. NANCARROW, R. J., 1977; Practices and precautions with pesticides - a study of knowledge and behaviour of growere towards pesticides; Project submitted as part of the requirements for Diploma of Agricultural Extension, University of Melbourne, Australia.



3. ASLIN, H. L., R. CLAY and L. CROPPER, 1980; Pesticides in South Australia; University of Adelaide, Australia.
  4. PESTICIDES BRANCH, Department of Primary Industry, 1980; A manual of safe practice in the handling and use of pesticides; Australian Government Publishing Service, Canberra, Australia.
  5. ANON., 1979; Code of Practice for safe use of pesticides; Commonwealth Scientific and Industrial Research Organization, Melbourne, Australia.
  6. ANON., 1980; Namoi environmental study; State Pollution Control Commission, Sydney, Australia.
  7. LENNE, B. D., Department of Agriculture, New South Wales, 1981; Personal communication.
  8. DEPARTMENT OF THE ENVIRONMENT 1975; Approved method of disposal of pesticides and pesticide containers, Tasmanian Journal of Agriculture 46, 81-85.
  9. a. ANON., 1977; Recommendations for the control of noxious weeds in Victoria, p.5., Bulletin No. 3E, 1977; Department of Crown Lands and Survey, Victoria, Australia.
  - b. ANON., undated; Disposal of pesticide containers and surplus pesticide, (wall chart); Environment Protection Authority, Melbourne, Australia.
  - c. ANON., 1979; Disposal of pesticide containers and surplus pesticide, Agnote 39/79; Department of Agriculture, Victoria, Australia.
- All of this information, whilst accurate, was brief and aimed at the farmer.
10. a. ANON., 1971; Disposal of containers and unwanted pesticides, (wall chart); Agricultural and Veterinary Chemicals Association, Sydney, Australia.

10. b. ANON., 1980; Farm storage of agrivet chemicals, AVCA Code No. 2., (wall chart); Agricultural and Veterinary Chemicals Association, Sydney, Australia.

All of this information, whilst accurate, was brief and aimed at the farmer.

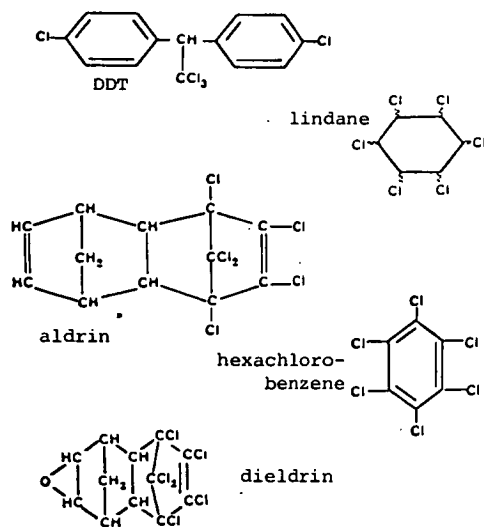
11. CRIBB, J., 'National Farmer', Canberra, 1981; Personal communication.
12. ANON., 1981; The storage and handling of pesticides, Australian Standard 2507 - 1981; Standards Association of Australia.
13. a. HOUSE OF REPRESENTATIVES STANDING COMMITTEE ON ENVIRONMENT AND CONSERVATION, 1982; Hazardous chemical wastes - storage, transport and disposal, 84 pp., Australian Government Publishing Service, Canberra, Australia.
- b. ANON., 1981; Incineration facilities for industrial liquid waste disposal - a feasibility study, 114 pp.; Environment Protection Authority, Melbourne, Australia.
- c. ANON., 1981; Disposal of intractable wastes in Victoria - a draft strategy, 92 pp., 4 refs.; Environment Protection Authority, Melbourne, Australia.
- d. ENVIRONMENTAL COUNCIL, and CONFEDERATION OF AUSTRALIAN INDUSTRY, 1981; Management and disposal of hazardous industrial wastes; Maunsell and Partners, Pty. Ltd., Canberra, Australia (in press).

## APPENDIX II

### Chemical Structure of Pesticides

#### INSECTICIDES

##### Organochlorine compounds



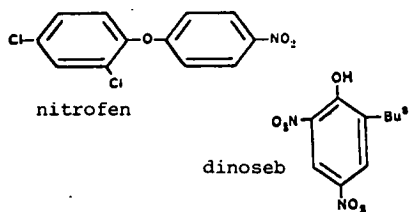
##### Miscellaneous

lead arsenate

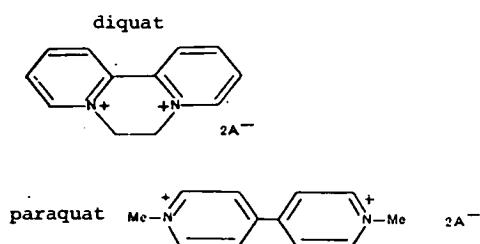


##### HERBICIDES

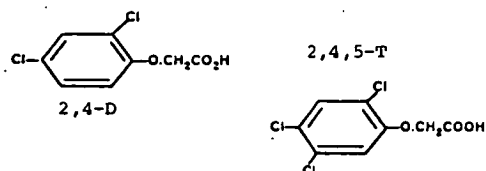
##### Nitrophenols



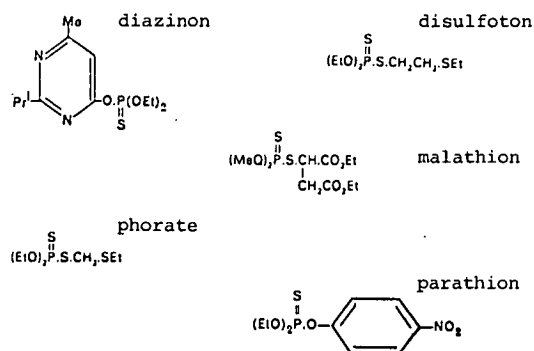
##### Bipyridyls



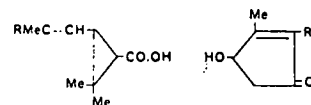
##### Phenoxyacetics



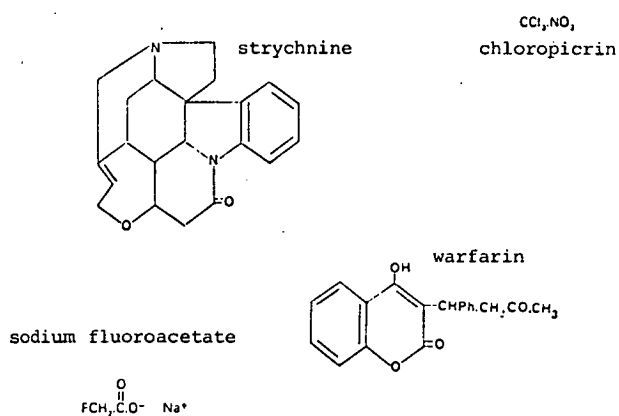
##### Organophosphorus compounds



##### Pyrethrins



##### RODENTICIDES



##### MISCELLANEOUS

formalin



# APPENDIX III

## Poisonings by Pesticide in Australia

Poisonings by pesticides, fertilizers or plant foods<sup>1</sup>.

Year	Sex	Age (years)									Outcome			
		0-4	5-9	10-14	15-24	25-39	40-59	60+	Unknown	Total	Fatal <sup>3</sup>	Unaff- ected	Mildly Ill	Seriously Ill
1971 <sup>2</sup>	Both	308								413	5(4)	163	220	30
1972 <sup>2</sup>	Both	251								324	1	152	154	18
1973 <sup>2</sup>	Both	188								254	1(1)	132	118	4
1974	Male	174	18	4	3	4	6	1	19	229	2(1)	193	30	6
	Female	110	10	7	1	4	2	1	8	143	-	117	26	-
1975	Male	184	11	4	4	3	2	-	6	214	-	191	22	1
	Female	145	7	3	5	4	4	-	-	168	1	142	21	5
1976	Male	161	10	3	5	3	5	1	22	210	2 (1)	173	32	5
	Female	171	6	2	3	3	3	2	16	206	1	181	24	1
1977	Male	210	18	5	4	3	6	1	44	291	-	252	33	6
	Female	160	8	2	5	3	4	3	27	212	1(1)	180	27	5
1978	Male	218	28	13	7	5	4	3	67	345	1	249	89	7
	Female	176	8	3	3	6	1	1	47	245	-	197	47	1
1979	Male	257	36	12	9	9	7	3	106	439	-	322	109	8
	Female	212	8	13	10	6	4	2	68	323	-	251	67	5
1980 <sup>2</sup>	Both	518								757	0	525	216	16

Poisonings by Pesticide in Australia

APPENDIX III

Whilst these poisonings are attributed to pesticides, fertilizers or plant foods, those reported are essentially caused by pesticides alone, and would have occurred mainly in a household situation<sup>4</sup>. In addition to the suicides noted under 'Fatal', a number of attempted suicides are included in the three other 'Outcome' columns. For 1979, for example, the total number of attempts was 20, of which none succeeded. This attempt rate represented in that year approximately 2½% of total poisonings. These figures are based only on voluntarily reported cases, and probably represent about 10% or less of total actual cases<sup>4</sup>.

A review of data compiled by the Tasmanian Poisons Information Centre<sup>5</sup>, which is one input into the figures above, showed some detail on the product/chemical involved, the route of absorption, the locality where the incident occurred, and age or species (some animal reports) of the patient. No information on how the poisoning occurred was gathered. No aid in assessing the issues discussed in this paper was therefore possible.

- 
1. ANON., 1979; Poisons reporting; Commonwealth Department of Health, Canberra, Australia.
  2. Complete figures not available.
  3. Number of suicides is given in brackets.
  4. HEYDE, T. E., National Poisons Information Service, Commonwealth Department of Health, 1981; Personal communication.
  5. ALI, D. R., and E. HOLMES, Royal Hobart Hospital, 1980; Personal communication.

APPENDIX IV

Effect Ratios of Pesticides<sup>1</sup>

Parameter	Herbicides	Fungicides	Insecticides	Other Pesticides
Bacterial numbers	1.20	3.50	1.30	1.00
Nitrification	1.40	0.54	0.82	0.32
Denitrification	1.82	i.d.a.	i.d.a.	i.d.a.
Rhizobia and legume nodulation	0.94	1.00	0.78	i.d.a.
Free-living, N <sub>2</sub> -fixation	1.65	i.d.a.	1.75	i.d.a.
Fungi and actinomycetes	1.09	0.5	1.43	0.55
Pathogens and their antagonists	0.81	4.00	i.d.a.	i.d.a.
Algae	0.45	i.d.a.	i.d.a.	i.d.a.
Cellulolytic activity and O.M. degradation	1.31	i.d.a.	1.10	0.62
Respiratory activity	0.91	0.40	2.00	1.40
Other enzymic activity	1.70	0.44	2.00	0.66
Ammonification	1.74	1.30	1.84	1.20

*This concept is one in which an attempt is made to obtain an overall guide to, or summary of, the general effects that a particular group of pesticides may have on certain soil microbiological processes. It cannot be considered to be unequivocally accurate for individual pesticidal formulations. All stimulatory effects and instances where there is no effect are added and designated as positive. Similarly, all inhibitions are added together and designated as negative. The ratio of positive to negative effects thus describes the effect ratio. The number of soil-types and pesticides used and whether or not increases followed by decreases of population numbers or activities occur have been taken into account in assessing the overall effect ratio of pesticides on a particular soil microbiological process.*

1. This table and the comment below are taken directly from ANDERSON, J. R., 1978; Pesticide effects on non-target soil micro-organisms, in: Hill, I. R. and S. J. R. Wright (eds.), Pesticide Microbiology, pp.313 - 533; Academic Press Inc., London, U.K.

APPENDIX V

Comparative Assessment of Different Methods  
of Disposal of Dilute Pesticides<sup>1</sup>

Method	Criteria					
	Environ- mental Safety	Effect- iveness	Pesticide Applicab- ility	Availab- ility	Applic- ator Factors	Total
Land cultivation	30	15	25	22	17	108
Soil mounds	45	20	30	22	18	135
Soil pits	35	15	30	14	19	113
Evaporation basins	35	15	25	17	20	112
Chemical treatment	45	30	20	25	11	131
Biological treatment	30	25	15	15	4	99
Adsorption	55	15	15	25	9	119
Transport and incineration	39	35	20	22	14	130

- 
1. SCS ENGINEERS, 1979; Disposal of dilute pesticide solutions, p. 90, SW-174c; prepared for the Office of Solid Waste, Environmental Protection Agency, U.S.A.

APPENDIX VI

Pesticides approved by the Ministry for Agriculture,  
Fisheries and Food (U.K.) for disposal onto cereal stubble

acephate	2, 4-D	ethoxyquin*
ametryne	dalapon	etridiazole
amitraz*	daminozide	etrimfos
aminotriazole	dazomet	
asulam	2, 4-DB	
azinphos-methyl	demephion	fenitrothion
azinphos-methyl+	demeton-S-methyl	fentin acetate with maneb
demeton-S-methyl	derris*	fentin hydroxide
sulphone	2, 4-DES	flamprop-isopropyl
aziprotryne	desmetryne	flamprop-methyl
	di-allate	flufenprop-isopropyl
	diazinon	fluotrimazole
barban	dicamba (cereal	fonofos
benazolin mixtures	herbicides only)	formetanate*
benodanil	dichlofluanid	formothion
benomyl	3, 6-dichloropicolinic	
bentazone	acid	glyphosate
benzoylprop-ethyl	dichlofop-methyl	
BHC sprays	dichlorprop	
binapacryl*	dichlorpropene	HCH sprays
bromofenoxim	dichlorvos	heptenophos
bromoxynil	dicloran*	
bupirimate*	dicofol*	imazalil
	difenzoquat	iodofenphos
captafol	diflubenzuron*	ioxynil
captan*	dimethoate	iprodione*
carbaryl	dimexan	isocarbamid
carbendazim	dinitramine	isoproturon
carbetamide	dinobuton*	
carbofuran	dinocap*	
chloroaniformethan	dinoseb	lenacil
chlorbromuron	dioxathion*	lime sulphur*
chlorfenprop-methyl	diphenamid	linuron
chlorfenvinphos	diquat	
chloridazon	disulfoton	malathion
chlormequat	ditalimfos*	maleic hydrazide
chlorothalonil	dithianon*	mancozeb
chloroxuron	DNOC in petroleum oil*	maneb
chlorpropham	dodemorph*	manganese and zinc
chlorpyrifos	dodine*	dithiocarbamate
chlorquinox	drazoxolon*	complex
chlorthal-dimethyl		manganese, zinc, iron
chlortoluron		dithiocarbamate
copper	EPTC	complex
cufraneb	ethiofencarb	MCPA
cyanazine	ethirimol	MCPB
cycloate	ethoate-methyl	mecarbam*
cyhexatin*	ethofumesate	mecoprop

\* Dilute to rate recommended for high volume application and spray at approximately 340 litres per hectare.



menazon	paraquat	streptomycin*
mephosfolon	parathion*	sulfallate
mercuric chloride	pendimethalin	sulphur
mercuric oxide	permethrin	
metaldehyde	pentanochlor	2, 3, 6-TBA
metamitron	petroleum oils*	TCA
methabenzthiazuron	phenmedipham	tecnazene
methidathion*	phorate	terbutryne
methiocarb	phosalone*	tetrachlorvinphos
methomyl	phosphamidon	tetradifon*
methyl isothiocyanate	pirimicarb	thiabendazole*
metobromuron	pirimiphos-ethyl	thiofanox
metoxuron	pirimiphos-methyl	thiometon
metribuzin	polyram	thiophanate-methyl
mevinphos	prometryne	thiram
monolinuron	propachlor	tridimefon
	propham	tri-allate
nabam	propineb	triazophos
l-naphthylacetic acid	propoxur*	trichlorphon
nicotine*	pyrazone	tridemorph
nitrofen	pyrazophos*	trietazine
nitrothal-isopropyl		trifluralin
	quinomethionate*	triforine
	quintozene*	
oil herbicides		
omethoate		vamidothion*
oxamyl	schradan*	
oxydemeton-methyl	sodium monochloracetate	
	spray additives	zineb

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\* Dilute to rate recommended for high volume application and spray at approximately 340 litres per hectare.

## APPENDIX VII

### Instructions for Australian Farmers on Disposal Techniques

(Issued by the Agricultural and Veterinary Chemical Association)

AVCA

## DISPOSAL OF CONTAINERS AND UNWANTED PESTICIDES

### FOREWORD

Considerable care and wisdom are required in establishing acceptable procedures for the disposal of unwanted materials, which are the by-products of modern living. Disposal of unwanted pesticides and containers can be regarded as a rather special problem. Careless disposal of unwanted pesticides or containers, in some circumstances, can create a hazard for humans, livestock and wildlife. Improper disposal procedures may cause contamination of streams and water supplies.

The Agricultural and Veterinary Chemicals Association is to be commended for preparing and circulating "Disposal of Containers and Unwanted Pesticides". I sincerely hope that all persons who are associated with pesticides and their use will read and heed the instructions contained in this important document.

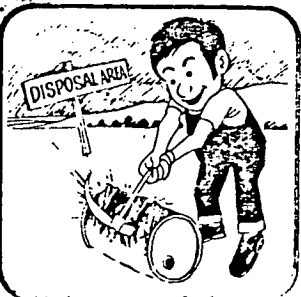
IAN SINCLAIR  
Minister for Primary Industry



Selecting disposal site



Returning to supplier



Destroying to avoid re-use



Burning combustible containers

Empty containers and unwanted pesticides can be serious hazards if they are not disposed of properly. On the one hand there is hazard to the general public, children in particular, while on the other hand, risk of contamination of environment and hazard to wildlife is becoming increasingly recognized. The immediate effects of faulty disposal may be readily seen as sickness and death in people or animals but the long term effects often pass unnoticed for months or years. The long term effects now being seen in some overseas countries can be prevented in Australia. Safe disposal is essential and is an important responsibility of every person involved in the handling and application of pesticides.

### Selection of Disposal Site

Select a disposal site that will be used only for surplus pesticides and pesticide containers. It should not be an area that might later be returned to crop land or some other use. It should be well away from homes, wells, streams, crops and livestock. Level ground is best because it will let the residue be absorbed through the soil and lessen the chances that it will be carried away in water run off. Sandy soil is preferred. Do not select the site on the watershed of a water supply or where livestock have access to it. In addition, avoid deep pits, creek beds, erosion gullies, quarries, "sinks" and sites within the normal range of ground water levels.

### Empty Containers

Before disposing of any containers, ensure that they are rinsed at least twice with water and the rinsing water is preferably added to the spray tank to avoid waste of pesticide and money. Double rinsing will remove the greatest portion of the container's contents.

#### 1. Large Containers

- Before disposing of large containers, check for remains of pesticide, emptying this into a pit on the container site in a place where contamination of water sources will not occur. Remember to double rinse the containers with water after emptying.
- Do not convert empty drums or barrels into livestock feed troughs, water storage containers or raft floats. They could be sources of food or water contamination.
- Dispose of large metal drums, e.g. 10 and 44 gallons, in one of these ways. (Do not forget to double rinse them before return.)
  - Return them to the supplier; or
  - Seal them to a firm dealing in used drums or barrels that is equipped to neutralise the toxicity of adhering materials. Contact your pesticide dealer for the names and addresses of such firms in your State; or
  - Take them to a sanitary land fill type of dump. Inform the operator of the dump that the drums contained residues of poisonous materials; warn him that poisonous vapours may be produced if the containers are burned. Before leaving, remove lids or bungs from the containers; chop holes in the containers with a sharpened pickaxe to prevent re-use. Make sure the site cannot contaminate a water supply; or
  - If none of the preceding disposal means are available to you, find a private disposal site of the type described above which you will use only for empty containers and unwanted pesticides. Correct site selection is most important. Before leaving, again ensure lids or bungs are removed from the containers and chop holes in them with a pickaxe to avoid re-use.

#### 2. Small Containers

Before disposing of small containers make sure they have been doubly rinsed with water. Small containers may be disposed of at a public dump or buried at least 18 inches deep at a private disposal site. First remove the caps or lids, punch holes in metal containers; crush glass containers. Do not make rafts from them and contaminate water ways and do not convert them into feed containers. Remember small containers represent the majority which will be disposed of in Australia.

#### 3. Combustible Containers

Burn combustible containers except herbicide containers unless the container label warns against burning. Do this when the wind will not cause contaminated smoke to drift over nearby homes, people, livestock, crops or the person doing the work. Some municipalities have restrictions against burning; consult local authorities before burning containers.

Caution: Drums or bottles may be under the pile to be burned. Make sure bungs are off or containers are punctured to prevent explosions.

#### 4. Herbicide Containers

Disposal of some herbicide containers, particularly hormones, requires extra care to prevent crop damage. Take the precaution of double rinsing before disposal, preferably tipping the rinse into the spray vat for use but, if not, into the disposal pit. Disposal of herbicide containers can then proceed as follows:-

- Do not burn them. When herbicides or defoliants volatilise, the resulting vapours may be poisonous to humans and they may damage nearby plants, crops or shrubbery. Herbicides or defoliants containing chlorates may explode when heated.
- Break glass herbicide containers. Chop holes in top, bottom and sides of metal containers so they cannot collect water or be re-used, or crush them under a tractor wheel or with an axe or sledge hammer. Also crush fibre drums, cardboard and paper containers. After breaking, crushing or puncturing them, bury the containers at a depth of 18 inches or more at a safe disposal site, or take them to a dump that does not burn its refuse.

### Unwanted Pesticides (Including surplus in spray vats)

First, offer to give unwanted pesticides to a responsible person in need of the materials. If this is not practicable, dilute the pesticide to spraying strength. Select a disposal pit at least 18 inches deep and spread a bag of lime over the bottom. Pour the diluted pesticide into the pit and allow it to soak in. Then cover with several inches of soil. Do not take unwanted pesticide to an incinerator.

With the compliments of:

APPENDIX VIII

Method for Disposal of Sheep Dip, Tasmania<sup>1</sup>

AGDEX 686

# Safe disposal of used sheep dip

by R.J. Gillham,  
Veterinary Officer

Sheep dips remain active, and consequently dangerous, for some time after they are used.

If they are disposed of carelessly they can contaminate water courses and dams and so endanger humans, stock and fish. In fact, most sheep dips carry a warning on the label that says, in effect: 'Do not contaminate dams, rivers or streams with the chemical, waste liquid or used containers.'

One way to dispose of sheep dip safely is to pour it into a covered, rubble-filled drainage pit like the one described and illustrated below.

## Size

Three times the volume of the material to be disposed of. For example:

Pit Size	Amount of Waste
20 cubic metres	6750 litres
5.4	1800
0.6	200

## Rubble fill

Coarse stone, 100-250 mm in diameter.

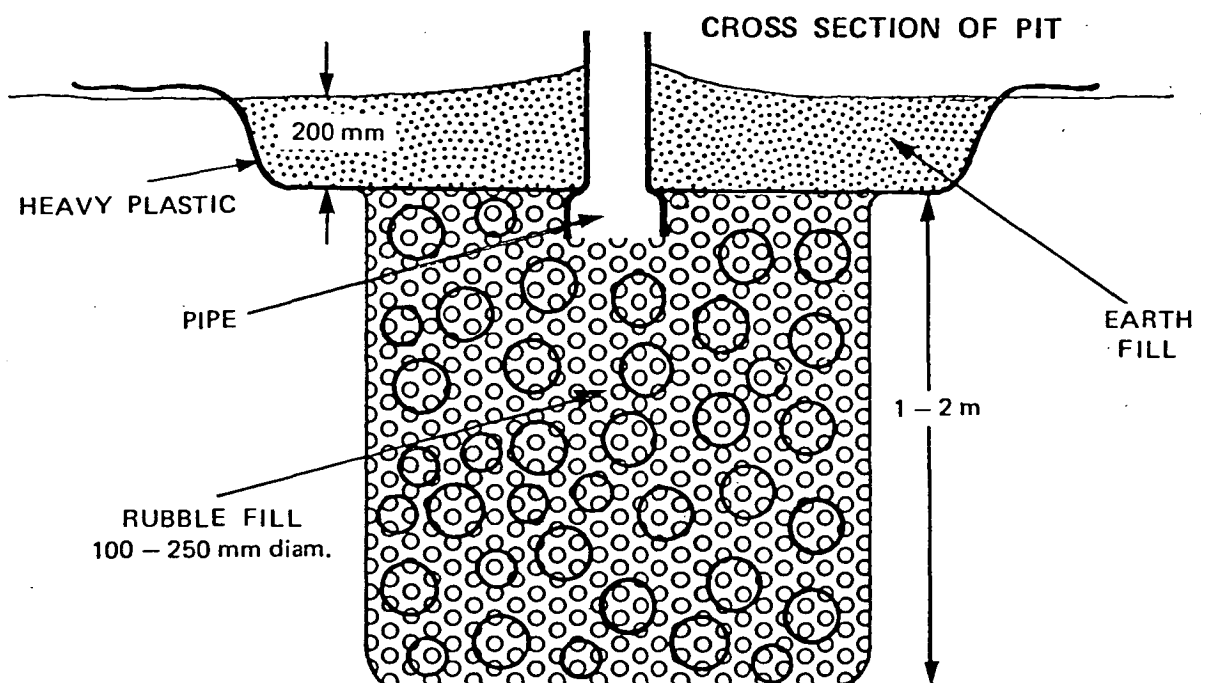
## Cover

Cover the rubble with heavy plastic and then cover this with soil about 200 mm deep. The waste is poured into the pit through a pipe as shown in the diagram.

## THE PIT

### Site

A convenient, dry slope near the dip but not in an area likely to be an underground drainage channel.



1. GILLHAM, J., 1980; Safe disposal of used sheep dip; Farmnotes No. 34/80  
Department of Agriculture, Tasmania, Australia.

APPENDIX IX

Survey of Australian Pesticide Labels for their Information Content  
on Pesticide and Container Disposal, and Pesticide Storage

As part of this general project, 29 pesticide manufacturers in Australia were contacted, and at least two or three sample pesticide labels (of their own choice) as well as any information on pesticide and container disposal, were requested. No company-produced literature or information was forthcoming, but a total of 79 different labels were received. (The number of products registered in Tasmania is between 450 and 500.) The number of labels supplied by each company varied from one to 18, and because the letter written to the companies outlined the general nature of this project, it is reasonable to assume the sample is at least 'average' for its content of information on disposal and storage.

Labels bore mandatory cautionary statements at the top, and at other locations, further cautionary statements relating to environmental matters. These statements referred generally to aspects of normal pesticide handling, but could be construed as applicable to disposal also. No label gave instructions on how to dispose of waste pesticides, either concentrated or tankmix, although occasional reference to clean-up of spills was made.

Whilst most labels suggested that empty containers should be rinsed, only a small number suggested that they should be burned, crushed or buried. Where the issue of container disposal was mentioned, it was generally in such terms as "dispose of safely", or "dispose in an approved manner", or "destroy container". Approximately 75% of labels made some reference to container decontamination or disposal<sup>1</sup>. Labels were generally more emphatic about what should not be done, rather than what should be done. In relation to disposal, among other things, a total of five basic statements appear on labels (not necessarily in these words): (i) do not contaminate water, food or feed; (ii) wash out the container; (iii) dispose of the container; (iv) do not re-use the container; and (v) do not expose to

fish, birds or wildlife. These five statements appeared on labels in different wordings and combinations, and with differing frequencies which did not generally exceed three. These differences reflect different active ingredients as well as differing company philosophies.

Instructions for storage of pesticides appeared on 71% of labels<sup>1</sup>, and similar to disposal instructions, varied in wording, combinations of statements and frequencies of statements. There were eight basic statements: (i) the mandatory "keep out of reach of children" appears near the top of every label; (ii) storage of pesticides should be in cool areas, and not in elevated temperatures, or near sparks of open flame; (iii) storage areas should be away from feed, foodstuffs, food-containers and eating utensils; (iv) storage areas should be away from fertilizers, seeds and other pesticides; (v) storage areas should be well ventilated; (vi) pesticides should be stored only in the original container; (vii) containers should be tightly closed; and (viii) stored pesticides should be behind lock and key. Additionally, there were sometimes precautionary statements for specific pesticides. The most commonly appearing statements were those referring, firstly, to separation of stored pesticides from seeds, fertilizers, etc., and secondly, to original containers, tight closure and a secure area. Reference specifically to lock and key was relatively rare.

In addition to the label comments described above, it should be noted that pesticide labels refer routinely to such things as first aid measures for poisoning, cleaning of apparatus, general safety precautions, handling and consumption of treated crops, etc.

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1. Because the philosophies of the different manufacturers seem to influence content of labels, the differing number of labels coming from each company that were considered, render these percentage statements of limited value.

APPENDIX X

Instructions for Australian Farmers on Correct Pesticide Storage  
(Issued by the Agricultural and Veterinary Chemicals Association)

THE AGRICULTURAL  
& VETERINARY  
CHEMICALS ASSOCIATION  
OF AUSTRALIA

GPO BOX 3968  
SYDNEY, NSW 2001  
TELEX: 71356



8TH FLOOR, 60 YORK ST.  
SYDNEY, NSW 2000

TELEPHONE: 02 2900700  
AFTER HOURS: 02 843539

AVCACODE No. 2

FARM STORAGE OF AGRIVET CHEMICALS

1. STORE in a separate locked building or room away from children and animals. This should be cool and dry with good ventilation, low humidity, free from water leaks and possible hose spray.
2. Keep all containers SEALED. If a container is opened or broken, reseal as soon as possible.
3. NEVER store in UNLABELLED CONTAINERS.
4. NEVER store in FOOD CONTAINERS.
5. Store herbicides in a SEPARATE ROOM (or clearly defined sub-division) from other pesticides such as insecticides and fungicides.
6. Check regularly for LEAKING CONTAINERS and handle as per AVCA "Disposal of Pesticide Spills".
7. Dispose of EMPTY CONTAINERS as per AVCA "Disposal of Containers and Unwanted Pesticides".
8. Have SOAP AND WATER readily available and wash after handling or using these products.
9. Use PROTECTIVE CLOTHING, launder after use and store away from pesticides.
10. Always READ AND HEED THE LABEL and carefully follow instructions for storage, safety directions and first aid.
11. Do not PURCHASE more than one season's supply of pesticides.

EMERGENCIES

1. In case of FIRE, keep away from smoke and fumes.
2. Check your FIRE EXTINGUISHER. Is it the correct type for the material involved? Has it been serviced regularly? If in doubt, check with your local fire authority.
3. Check that your HOSE or EMERGENCY WATER SUPPLY will reach the storage area.
4. In case of a SPILL, beware of fumes and handle as per AVCA "Disposal of Pesticide Spills".
5. Clearly MARK your shed "DANGER - PESTICIDES"
6. EMERGENCIES - Record the following numbers AT YOUR TELEPHONE:  
DOCTOR .....  
HOSPITAL .....  
POISONS INFORMATION CENTRE .....  
AMBULANCE .....  
FIRE .....  
STATE EMERGENCY SERVICES .....

PLEASE NOTE: AVCA issues this document for guidance only.  
Each individual must accept responsibility for his own situation.



APPENDIX XI

Acts in Australia Relating to Control of Pesticides

Queensland

Agricultural Standards Act 1952 - 1972  
Stock Acts 1915 - 1976  
Health Acts 1937 - 1976

New South Wales

Pesticides Act 1978  
The Stock Foods and Medicines Act 1940  
The Poisons Act 1966  
Public Health Act 1961  
Hazardous Goods Act 1970

Victoria

The Pesticides Act 1966  
The Stock Medicines Act 1958  
The Stock Foods Act 1958  
The Health Act 1958  
The Poisons Act 1962  
The Household Insecticides Regulations 1973

South Australia

Agricultural Chemicals Act 1955  
Stock Medicines Act 1939 - 1973  
Stock Foods Act 1941 - 1956  
Dangerous Drugs Act 1934  
Food and Drugs Act 1908 - 1976

Western Australia

Health Act 1911 - 1979  
Veterinary Preparations and Animal Feeding  
Stuffs Act 1976  
Poisons Act 1964 - 78

Tasmania

Pesticides Act 1968  
Stock Medicines and Fertilizers Act 1950  
Poisons Act 1971 - 73  
Public Health Act 1962  
Environment Protection Act 1973

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Beyond these, there are further Acts relating to transport, manufacture, etc., which have a less direct bearing on pesticides.

APPENDIX XII

Calculation of Residual Pesticide  
in Containers Reaching Tips

On Page 229 is a detailed breakdown of the sizes of containers accumulated annually in Tasmania. Considering only liquid pesticides, which accounted for nearly 80% of non-burnable containers, the average composition of each 100 discarded containers can be calculated (see table below). Archer<sup>1</sup> found the residues left in pesticide containers of 5, 20 and 200 litres after a thorough draining were 14, 70 and 90 ml respectively. The proportion remaining was higher as container size decreased, and the 14 ml remaining in the 5 L container corresponded to 0.37% of total volume. Ignoring the fact that viscosity, temperature, type of container, etc., all influence draining, these figures can be applied to local accumulations to obtain an approximate indication of residue volumes.

Container Size	No. of Units per 100	Residual Volume <sup>2</sup> in Container	Total Residue <sup>3</sup>
500 ml	0.6	2 ml	1 ml
1 litre	3.6	4 ml	14 ml
2 - 2½ litre	3.6	8 ml	29 ml
5 litre	49.9	14 ml	699 ml
10 litre	2.5	37 ml	93 ml
20 litre	37.3	70 ml	2 611 ml
200 litre	1.4	90 ml	126 ml
Miscellaneous	1		
	100		3 573 ml

For every 100 containers reaching a tip approximately 3.6 litres of pesticide concentrate arrives as residue. For the average 350 containers reaching the tip the volume would be approximately 12 litres.

---



1. ARCHER, T. E. and D. P. H. HSIEH, 1973; Detoxication of metal drums from emulsifiable concentrate formulations of parathion, Pesticide Science, 4, 69-76.
2. These residual volumes are extrapolated from the residue of 0.37% of total volume remaining in the smallest container (5 litre) measured. This would, in fact, understate the proportion of residue remaining, but these smaller containers, overall, are relatively insignificant.
3. Figures in this column are rounded to the nearest whole number.

## ANNEXE

ANNEXE

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## ANNEXE

This part of the document contains a detailed presentation of the farmer survey carried out as part of this project. It covers the more important aspects of the design and administration of the questionnaire, as well as an outline of the actual sample. A detailed primary analysis of the survey is given, and a statistical analysis of a small number of the more important possible correlations and differences concludes the section.

The survey has been handled as a separate unit in this treatise for two main reasons. Firstly, if complying with the normal conventions of form as found in the body of this document, it would be difficult to describe the survey in an integrated, thorough and digestible way, particularly in relation to the segment which analyses the survey results. Secondly, the majority of readers would not require the amount of background and analytical detail presented in the Annexe in order to gain a good appreciation of the central topic. However, because this survey is the first, and quite possibly the last, of its type in Australia, it seems appropriate that these details be accessibly recorded, particularly as much of the material could be of interest in other areas of pesticide and safety research.

The findings of the survey are summarized in Chapter 4 in the body of the text, together with other findings in Tasmania of relevance to the general theme. Chapter 4 also discusses at some length the implications of the total findings.

### 1. DESIGN OF THE QUESTIONNAIRE

Design and orientation of the questionnaire needed to take account of the source of the information sought, the method of information gathering, the possible problem of intrusive questions, and the order of questions in the questionnaire.

### 1.1 Source of information

Among other things, the survey sought to elucidate and quantify aspects of farmers' behaviour and knowledge in relation to handling of pesticides. Whilst officers of the Department of Agriculture, staff of organizations distributing pesticides, and others could probably provide reasonably accurate information on farmers' behaviour in relation to the storage and disposal of pesticides and containers, such information is likely to be generalized, biassed, and lacking in detail. It seemed better, therefore, to obtain the information from the farmer himself, but a short simple questionnaire for obtaining relevant information from the officers of the Department of Agriculture also seemed desirable.

### 1.2 Nature of interview

Oppenheim<sup>1</sup> presents a variety of reasons why a face-to-face interview is to be preferred over mailed questionnaires. The direct interview allows far greater flexibility than the mailed questionnaire because uncertainties in the mind of the subject can be clarified, and very importantly, answers probed where necessary. For the same reasons, the direct interview can be more complex than the mailed questionnaire, and there is not the same need to compromise questionnaire content because of length or interest.

Further, face-to-face interview will normally elicit far greater spontaneity and richness of answer. On the other hand, for reasons of time and cost, the direct interviewer does not normally cover the same number of subjects, and because of the interviewing technique, will almost inevitably produce bias of some sort.

There were further specific reasons why interview-technique seemed more suitable for this survey. Firstly, it seemed preferable to actually see how a farmer conducted his storage and disposal so that a more detailed, consistently assessed, and accurate impression of his approach would be possible. Secondly, the information sought was to be as much descriptive as it was quantitative, and the flexibility of the face-to-face is far more conducive to gathering qualitative information. Thirdly, if a questionnaire seeks information on knowledge of, and behaviour in the

same activity, it seemed likely that a temptation - conscious or sub-conscious - would exist to represent both as somewhat more similar to each other than they are in fact, and perhaps also better than they are in fact. Fourthly, because answers to some questions which could usefully be posed, could readily be obtained from books, charts, etc., held around the home, there was further reason to carry out the interview face-to-face. Finally, in the interests of completeness and fuller understanding of responses, it seemed worthwhile to be in a position to record asides, qualifying comment, etc.

### 1.3 Intrusive questions

Intrusive questions were handled with a variety of approaches. Firstly, as far as it was practicable without compromising the aim of the survey, wording of questions and probes was as unintrusive as possible. Secondly, recognizing that the general subject of pesticides can be somewhat emotive, and believing that some questions could be perceived as intrusive, a pilot questionnaire was tested among nine farmers not far from Hobart. The structure of the pilot questionnaire was very loose, resulting in a more conversational interview and permitting gentler introduction of questions with a potential for intrusiveness. The response to this pilot study, particularly in the areas expected to pose problems, was agreeably co-operative and unrestrained. This fact, together with the problems of collating loosely structured questionnaires, suggested that a more formal format with direct questions would probably succeed in its purpose.

A further tactic, aimed at allaying any apprehension arising from the nature of the questions, was the use of an introductory letter which guaranteed the interviewee confidentiality. In addition, the letter described the favourable response to the pilot interview, and also made clear the fact that the project originated in the University and not in government departments, private industry, or elsewhere.

### 1.3 Order of questions in the questionnaire

In order to gain the interest of the subject from the outset, it seemed desirable to put the question on attitudes right at the beginning. This



was followed by the more mundane questions relating to personal, farm and pesticide use details. From there the questions moved through aspects of knowledge, behaviour, sources of information, etc., in a relatively orderly way. Care was taken to differentiate between knowledge, behaviour and attitudes. Inspection of storage and disposal sites was left until the end of the questionnaire, so as not to interfere with the verbal assessment.

## 2. THE SAMPLE, AND ADMINISTRATION OF THE QUESTIONNAIRE

Because of the preliminary nature of the survey, it was decided that a survey of the whole State would be more useful than one of a particular area, or of a particular type of farm, etc. Further, it was decided that the sample should be restricted to the *bona fide* farmer, i.e., the farmer whose principal livelihood was farming. In taking this view, the hobby farmer, the part-time farmer and others were excluded from the sample. In some areas such as the Huon and Tamar Valleys, part-time and hobby farmers comprise a relatively high proportion of all farmers<sup>2</sup>, and in some respects, these farmers are different from the *bona fide* farmer. For example, there are sociological differences<sup>3</sup>, and their approach to farming is governed by a variety of factors which have no relevance to the *bona fide* farmer. The selection, then, only of *bona fide* farmers would be expected to embrace a group whose fundamental philosophies towards farming are similar, and who account for the vast majority of agricultural production in the State.

Some problems were experienced in finding a list from which to draw the sample. Lists held by the Australian Bureau of Statistics (6,000 names) and by the Tasmanian Department of Agriculture (more than 4,000 names) were inaccessible, and the 680 names listed under 'Farmer' in the Yellow Pages of the three Tasmanian telephone books represented a sample which was both small and biased. Finally, access was gained to the mailing list of 5,650 farmers of a widely circulated farmer publication. From this, 210 names of *bona fide* farmers were selected, and with appropriate advice, it was possible to stratify by geographic distribution and by enterprise type. The reason for stratification by enterprise is clear. In the case of geographical distribution, stratification was desirable to allow for differing opportunities for disposal, and also for exposure to differing sources of information such as distributors or Departmental

officers. It was in fact possible to stratify the geographical distribution so that either seven or eight farmers were selected from each of the Department of Agriculture Districts on mainland Tasmania. One disadvantage of the list ultimately used was its slight bias toward the better farmer.

Interviews were arranged by contacting the farmer by telephone in the evening. On this occasion the farmer was told that the survey was about pesticides, by whom it was being carried out, and that his name had been drawn at random from a list of more than 4,000. He was then asked if he was prepared to be interviewed. This conversation was also a time for screening out anyone whose principal livelihood was not farming, and anyone who did not use pesticides. In most cases, the interview took place the following day, and each day generally permitted four interviews which usually varied from a half to one-and-a-half hours. With a view to minimizing mileage, it was sometimes necessary to be a little inflexible in the timing of an interview, but mostly farmers were very co-operative if they had agreed to being interviewed.

At commencement, the farmer read the introductory letter, terminology and any initial queries were clarified, and the farmer was encouraged to expand or qualify his comments whenever he wished.

A total of 149 farmers were contacted by telephone in order to reach the total required sample of 100. Of those contacted, but not interviewed, 24 were unavailable for interview due to such things as heavy work load, death in the family, holidays, etc.; 16 were no longer farmers, never had been, or their present main livelihood was not farming<sup>4</sup>; five used no pesticides; and four were unwilling because of lack of interest, disenchantment with the Centre for Environmental Studies, or the belief that pesticides are not dangerous. (This latter comment in no way reflects the tone of the initial contact.) In addition to the 100 farmers, three spray contractors and a distributor were visited, but only matters of disposal were discussed. The final sample is characterized in the tables which follow:

Age Range (Years)	Survey (%)	A.B.S. <sup>5</sup> (%)
0 - 19	0	1.2
20 - 29	5	12.3
30 - 39	23	19.6
40 - 49	27	21.3
50 - 59	26	25.1
60 +	19	20.5

Table 10 : Age distribution of sample and of the population.

No statistical test was carried out to determine the significance, if any, of the difference between the sample and population age distributions.

(Proceed to next page.)

Main Farm Enterprises	Survey (%)	A.B.S. <sup>6</sup> (%)
Beef	8.5	17.1
Beef/cereal	0.0	0.6
Beef/sheep	31.0	9.5
Sheep/cereal	4.0	1.8
Sheep	7.0	20.8
Dairy	25.5	24.6
Mixed	7.0	0.0 <sup>7</sup>
Orchard	4.0	7.2
Pigs	1.0	3.2
Vegetables, including potatoes	11.0	9.2
Other	1.0 (hops)	3.1
Total (a)	100.0	97.1
Poultry	0	1.1
Grapes	0	0.1
Cereals	0	0.9
Nurseries	0	0.8
Total (b)	0	2.9
TOTAL	100.0	100.0

Table 11 : Enterprise type in sample and in the population.

Interviewees were asked to name their two most important enterprises. The farm was classified as mixed when this term was used by the farmer, or when the importance of three or more enterprises could not be differentiated, but this classification did not appear in official statistics. The interviews did not adequately identify paired enterprises such as beef/cereal, etc., so the comparisons of pairs in the table, given in the interests of completeness, are not necessarily valid. In a study of this nature, close correlation of

sample and population composition is not critical; however, a comparison of behaviour of the different enterprise types did reveal very few statistically significant differences.

Whilst standard of education of the farmer is of some interest in this study, it was not formally assessed. However, in the course of interviewing it became apparent that standards varied through illiterate (the introductory letter and some other parts of the questionnaire had to be read to the subject) to university qualifications.

### 3. THE QUESTIONNAIRE

A.1

#### PRELIMINARY 'PHONE INTERVIEW

Q.1. I'm from the University of Tasmania and I'm doing a survey on some aspects of pesticide use in the State. Your name has been randomly chosen from a list of more than four thousand names. I wonder whether you are prepared to be interviewed at a time convenient to both of us.

No ☐ - proceed to Q.2.  
Yes ☐ - proceed to \*

Q.2. Could I ask why not?

End of interview

\* Could I ask some short, preliminary questions, please?

Q.3. In the course of farming or primary production, do you use any pesticides? (Clarify "pesticides" if necessary.)

No ☐ - proceed to Q.4 and Q.9  
Yes ☐ - proceed to Q.5

Q.4. Could I ask you why you use no pesticides? (Probe if necessary)

Proceed to Q.9.

A.2

Q.5. Is farming or primary production your most important source of income?

No ☐ - proceed to Q.9  
Yes ☐ - proceed to Q.6

Q.6. In terms of net earnings, what is the most important activity or enterprise on your property at present?

sheep farming (any type)  
beef cattle  
dairy cattle  
fruit production  
vegetable production  
cereal production  
other. Specify  
mixed enterprise. Specify

Q.7. Has this been the most important for more than a year?

No ☐ - proceed to Q.8 and \*  
Yes ☐ - proceed to page A.4.

Q.8. What was the previous most important enterprise on your property?

sheep farming (any type)  
beef cattle  
dairy cattle  
fruit production  
vegetable production  
cereal production  
other. Specify  
mixed enterprises. Specify

\* CONFIRM ADDRESS ETC. ON A.4.

Q.9. I'm going to read you six statements. For each, could you indicate whether you strongly agree, agree, are uncertain or indifferent, disagree or strongly disagree. (Repeat). Is that clear?

	Strongly agree	Agree	Uncertain/indifferent	Disagree	Strongly disagree
a. Pesticides are <u>essential</u> for successful farming or production on my property.					
b. There is nothing ethically wrong in using pesticides for their normal intended purpose.					
c. It would be preferable not to have to use pesticides on <u>this</u> property.					
d. In general, farmers do not use sufficient pesticides.					
e. Pesticides have contributed significantly to the success of agriculture in Australia.					
f. It would be preferable not to have to use pesticides on <u>any</u> property.					

Would you like to make any further comment on any of these statements?

End of interview

Could I please confirm your personal particulars?

Surname  
Christian names  
Address

Mr, Mrs. Ms, Miss, Dr.

Post code

'Phone ( )

You are: owner/manager  
manager  
share farmer  
other. Specify

Directions to property:



## Centre for Environmental Studies

University of Tasmania

Box 252C, GPO Hobart, Tasmania 7001

Telephone: 23 0561. Cables: Tasuni. Telex: 58150 UNTAS  
Ext. 633, or evening (002) 232421

November, 1980

Dear

### QUESTIONNAIRE ON PESTICIDES

You will recall that I spoke to you on the telephone not long ago. I would like to re-introduce myself: my name is David Dyson, and currently I'm studying at the Centre for Environmental Studies at the University of Tasmania. I am carrying out a survey on some aspects of pesticide use by farmers and other people, and this survey is being conducted right across the State and covers a variety of agricultural activities. Those whom I interview have been chosen at random from a list of more than four thousand farmers.

As with any survey of this type, you will want, quite naturally, some guarantee of confidentiality of the answers and information you give. Although I believe the questionnaire is essentially non-personal in nature, the Director of the Centre, Dr. Richard Jones, has countersigned this letter as a guarantee that the information you give will appear anonymously in the final report. In fact, a system of number coding ensures that I am the only person knowing who 'belongs' to each questionnaire. If, for any reason, the mention of names seems necessary, your specific and signed permission would be obtained beforehand. We expect that the final report will be of interest to some government departments, the agricultural chemical industry and perhaps others. However, the idea behind this survey came essentially from the University.

Not long ago, I carried out a small pilot survey, and despite the nature of a couple of questions, it was very pleasing to receive the full co-operation of those interviewed. If surveys like this are to be of any use, it is necessary that honest answers are given i.e. answers which reflect what you actually think and do, not what you believe you ought to think and do.

Finally, one of the questions I would like to ask you may require a little thought and time. The attached sheet asks for some information about your actual pesticide use. If you could complete this before I visit, that would be a great help.

I look forward to meeting you on at , and  
thank you in advance for your willingness to be interviewed.

Yours faithfully,

Dr. R. Jones

David Dyson

B.1

### PESTICIDE QUESTIONNAIRE

Do you have any queries about the letter I sent you? Are there any issues not raised in it you would like to discuss before starting?

I mentioned that this questionnaire concerns pesticides. For the purposes of this interview, a pesticide is a chemical used as a crop protectant, a rodenticide, a seed dressing or grain fumigant, external dip for animals, a herbicide, a pest repellent, a plant growth regulator, a fungicide, etc. It does not mean veterinary products other than external or pour-on dips, nor disinfectants. Is that all clear?

I want to get as much accurate information from you as I can, so if a question is not clear or if you wish to make additional comments, please do so. There are no right or wrong answers to questions. And please, give honest answers.

Any further query before commencing?

Q.1. Firstly, I would like to find out something about your general thoughts on pesticides, and so I'm going to read to you six separate statements. For each, could you indicate whether you strongly agree, agree, are uncertain or indifferent, disagree or strongly agree. Is that clear? (Show subject list of answers).

		Strongly agree	Agree	Uncertain/ indifferent	Disagree	Strongly disagree
a.	Pesticides are essential for successful farming or production on my property.					
b.	There is nothing ethically wrong in using pesticides for their normal intended purpose.					
c.	It would be preferable not to have to use pesticides on <u>this</u> property.					
d.	In general, farmers do not use sufficient pesticides.					
e.	Pesticides have contributed significantly to the success of agriculture in Australia.					
f.	It would be preferable not to have to use pesticides on any property.					

Would you like to make any further comment on any of these statements?

0.2. Into which decade does your age fall?

Teens	
Twenties	
Thirties	
Forties	
Fifties	
Sixties or more	

Q.3. Which of the following lives on this property:

Child or children aged six years or less	<input type="checkbox"/>
Free-roaming pets (e.g. dog, cat, but not budgie, fish etc.)	<input type="checkbox"/>
Working dogs	<input type="checkbox"/>
Commercial or other livestock including horses, goats etc.	<input type="checkbox"/>

Q.4. This question relates to your actual pesticide usage, and I asked in my letter whether you could perhaps answer the question before I called. Are you able to complete the table? (Probe any problems, difficulties and, in all cases, look at table. Where no work done, repeat the questions)

a. Was any of your pesticide spraying or application in the last 12 months done by contractor?

No ☐

Yes ☐ - all ☐

- some ☐

b. Could you please tell me, in relation to your total pesticide use on your property for the last 12 months

- (i) what pesticides were used? (Trade name, or generic name, and maker).
- (ii) what percent active ingredient (as on label) was in the product?
- (iii) size of each container emptied?
- (iv) number of each container?
- (v) what was the container made of? (Steel, tin, plastic, paper, cardboard, cloth etc.)

#### B.4

Product & Manufacturer	% Active Substance	Container Size(kg/lt)	No. of Containers	Container made of:-
<u>Example:</u>				

### B.5

Q.5. The farming community and the community at large hold a variety of opinions on pesticides. Overall, however, it seems clear that most people believe that correctly used pesticides have beneficial effects. Do you associate any actual or possible undesirable effects with the correct use of, or presence in containers on the farm, of pesticides? (Answer 'no', 'not a yes').

No	
Not sure	
Yes	

Could you explain why you believe that, please?

Q.6. Do you believe that pesticides stored on farms, or in the course of no preparation or use, could possibly lead to, or contribute directly to the following? Could you please answer with 'yes', 'not sure', 'no', free to make any additional comment. (Repeat question) (Ask only the not mentioned above in Q.5.)

	N	N/S	Y
allergy in humans			
infection			
worsening pest problems			
poisoning of humans			
death of birds			
short-sightedness			
resistant pest species			
ecological disturbance or damage			
fire			
skin irritation			

**Any comment:**

Q.7. Imagine that you had a case of a pesticide poisoning - either an adult or a child - on this property. Do you keep anything around the home or farm which could help you treat this person correctly and efficiently?

No ☐  
Yes ☐

- what do you keep? (Do not probe until first reaction is complete).

[Where necessary: Literature?  
Medicaments?  
Apparatus?]

Q.8. Do you know where you may obtain information on the treatment of cases of poisoning? (Subject not shown list)

P.I.C.  
doctor  
hospital  
book  
chart  
pesticide package label  
other. Specify  
" Specify

B.8

Q.11. Poisoning by pesticides can produce a variety of different signs or symptoms in the person poisoned. Could you name as many signs or symptoms as you can which could indicate that a person has been poisoned by pesticides? In other words, what might a person complain about, or what things could you observe about him, if he were poisoned?

Q.9. Have there been any cases of poisoning by pesticides on this property

a. of humans? No ☐ - proceed to Q.10b.  
Yes ☐ - proceed to Q.10a.  
b. of animals? No ☐ - proceed to Q.10b.  
Yes ☐ - proceed to Q.10a,b.

Q.10. a. What action did you take?

b. What action would you take in the case of human poisoning by pesticide?

B.9

Q.12. The State Department of Agriculture publishes quarterly its Journal of Agriculture. Irrespective of where you have obtained it from, and whether or not you read it, have you been, since the beginning of 1975,

a. a regular receiver of the Journal (i.e. all editions) ☐  
or, b. an occasional receiver of the Journal ☐  
or, c. a non-receiver of the Journal ☐  
or, d. other. Specify. ☐

Q.13. Probably, you have a number of sources of technical information on pesticides. Could you please look at this list and tell me which is your most important source, and which your second most important? (Show subject list)

a. Tasmanian Journal of Agriculture ☐  
b. other journals or publications ☐  
c. officers of the Department of Agriculture ☐  
d. other farmers ☐  
e. farmer organizations ☐  
f. representatives from the companies making the pesticides ☐  
g. literature or 'paper' advertising (i.e. not radio or T.V.) from the makers of the pesticides ☐  
h. personnel of agricultural chemical retailers or distributors ☐  
i. television ☐  
j. radio ☐  
k. University of Tasmania, or other university ☐  
l. other. Specify: ☐

Q.14. Are you, in general, satisfied with the quality and/or quantity of the technical information on pesticides, which you receive overall?

No ☐ - proceed to Q.15.  
Yes ☐ - proceed to Q.16.



Q.15. What aspects of the quantity and/or quality of your information on technical aspects of pesticides is unsatisfactory?

Quality? ☐  
Quantity? ☐

What suggestions do you have for improving its quantity and/or quality?

Q.16. Can you recall having seen or heard information on the correct method of storing your pesticides

No ☐ - proceed to Q.18.  
Yes ☐ - proceed to Q.17.

Q.17. Did you hear or see about the correct storage method. (Show subject)

- a. in a journal or publication?
- b. on radio or television?
- c. from your agricultural chemical supplier?
- d. from other farmers?
- e. from pesticide manufacturers?
- f. I'm not sure where from
- g. other. Specify:

Q.18. Can you recall having seen or heard information on the correct method of disposing of unwanted pesticides or pesticide containers?

No ☐ - proceed to Q.20.  
Yes ☐ - proceed to Q.19.

Q.19. Did you hear or see about the correct method of disposal. (Show subject)

- a. in a journal or publication?
- b. on radio or television?
- c. from your agricultural chemical supplier?
- d. from other farmers?
- e. from pesticide manufacturers?
- f. I'm not sure where from
- g. other. Specify:

Q.20. Do you ever find yourself left with a quantity of pesticide, for example, remaining after you have completely sprayed an area to be treated, or, alternatively, in its original form (as purchased), for which you have no use?

No ☐ - proceed to Q.23.  
Yes ☐ - proceed to Q.21 and Q.22.

B.12

Q.21. These unwanted pesticides, which you may have as liquids, powders, granules, gas or in other forms, can be handled in a variety of ways, and sometimes the farmer is uncertain of which is the best of the possible alternatives. Which of the following procedures did you follow with your unwanted pesticides? (Show subject list. Mark more than one, if appropriate.)

- a. burnt it
- b. threw it on my rubbish heap
- c. took it to the local tip
- d. threw it in a dam, creek, gully etc.
- e. buried it
- f. didn't know what to do, and still have it stored away
- g. applied it to crop etc.
- h. poured it down a drain
- i. poured it into the toilet
- j. put it into other containers
- k. left/poured it by the roadside
- l. poured it into a sump
- m. gave it away
- n. other. Specify

Could you please describe in detail how you went about this/these procedure(s).

Where buried: (subject not shown list)

Dilute to use strength ☐  
Hole of 18" ☐

Line with lime ☐  
Allow to soak in ☐  
Cover with soil ☐

When last did you do this?

And before that?

Approximately what quantity of pesticide was involved on these/this occasion(s)

kg

lt

B.13

Q.22. Someone says to you, "Your method of handling these unwanted pesticides has both good and bad points." Is that person right, or wrong, or partly right and partly wrong? Why?

\* Go to Q.24.

Q.23. Could you briefly explain why you never find yourself with a quantity of unwanted pesticide?

Q.24. If a farmer applies pesticides to his crops etc., he will from time to time have newly emptied pesticide containers on his property. He may, for example, accumulate these containers in a pile, use them for other purposes, do something else with them, or adopt a combination of some or all of these possibilities. Could you, please, describe as accurately as possible, what you do with your empty pesticide containers? Where there is more than one treatment, please mention each. (Subject not shown list).

double rinse with caustic soda/detergent	<input type="checkbox"/>	don't burn phenoxy-types	<input type="checkbox"/>
secure storage before disposal. No accumulation	<input type="checkbox"/>	burn paper, plastic, fibre, etc. but not hbc.	<input type="checkbox"/>
recycle large drums	<input type="checkbox"/>	non-burnables: break, puncture, crush, de-bung bury.	<input type="checkbox"/>
no re-use for raft, feed trough, water storage	<input type="checkbox"/>		
site (Q.38)	<input type="checkbox"/>		

Comment:

[ Probe: different treatment of different container types  
different treatment of different container contents  
is any application done by contract. If so, does contractor leave/take containers? ]

Q.25. Someone says to you, "Your method of handling empty pesticide containers has both good and bad points." Is this person right, or wrong, or partly right and partly wrong? Why?

Q.26. In order to do what you consider most appropriate with unwanted pesticides or pesticide containers, do you believe that help from outside the farm would be useful?

No ☐ - proceed to Q.28  
Yes ☐ - proceed to Q.27

Q.27. Who or what should or could help in this matter? How could help be given?

B.16

Q.28. Do you know of any legal restriction relating to the fate of pesticide containers or unwanted pesticides?

No ☐ - proceed to Q.30.  
Yes ☐ - proceed to Q.29.

Q.29. Could you describe, very briefly, the laws which you believe to exist?

Q.30. Are you aware of any type of facility in your district - but not on your property - where pesticide containers or unwanted pesticides may be disposed of?

No ☐ - proceed to Q.32  
Yes ☐ - proceed to Q.31.

Q.31. What are these facilities?

Do you use them? No ☐ - Why do/don't you use them?  
Yes ☐

B.17

Q.32. Are you aware, among your neighbours, friends, family, community leaders, other people in your area, of any strongly held views on the use of pesticides in general?

No ☐ - proceed to Q.35.  
Yes ☐ - proceed to Q.33, Q.34.

Q.33. To which of the following groups does/do this person/people belong?

Immediate family	<input type="checkbox"/>
Relations	<input type="checkbox"/>
Neighbour	<input type="checkbox"/>
Member of organization. (e.g. Dept. Ag., F. & G., conservation group etc.)	<input type="checkbox"/>
Other. Specify:	<input type="checkbox"/>

Q.34. What, briefly are their views?

Q.35. Could I please, see where you store your pesticides? Is this your total stock, or is some stored or lying elsewhere? (Subject not shown list).

specific cupboard, container ☐

behind locked door ☐

away from food, feed, water ☐

in original container ☐

containers and labels intact ☐

herbicides, defoliants  
separate ☐

Comment: \_\_\_\_\_

Q.36. You have here some opened containers. What is intended for the contents (of each)?

Q.37. Someone says to you "The way in which you store your pesticides has good and bad points." Is this person right, or wrong, or partly right and partly wrong? Why?

Q.38. Could I please see where you dispose of your pesticide containers and unwanted pesticides? Is this the only place? (Evaluate site)

End of interview

B.20

Impression of house

Impression of farm

VG	G	Fair	B	VB

Education?

Other?

#### 4. PRIMARY ANALYSIS OF FARMER SURVEY

In this segment, the questionnaire itself receives comment. Aims of the questions (which are not always immediately clear) are outlined, and shortcomings of the questionnaire are described. Other problems with questions are mentioned, but principally, the responses of the interviewees are analysed. The segment may be read in its entirety, or, by omitting the comment in the outlined frames which relates largely to the questions themselves, the reader may glean full detail of the actual survey. These findings are summarized and discussed in Chapter 4, and where possible, comparisons have been made with other related Australian surveys. Photographs of some of the more notable aspects of this survey can also be found in Chapter 4.

It bears repeating here, that this survey is the first of its type carried out in Australia, and is therefore only exploratory in nature. Mathematical treatment of the data, therefore, has been very basic, and the treatment has emphasized qualitative aspects. For these reasons, and also because of the unlikelihood that further such surveys will be carried out, the coverage of this survey has been considerably greater in breadth than depth.

The principal overall aim of the questionnaire was, firstly, to elucidate and perhaps explain farmers' knowledge of, and practices in the areas of pesticide and pesticide container disposal. Secondly, it was hoped to find whether these practices cause any significant damage to man or the natural environment. Because the survey had the potential to highlight aspects of farmer behaviour which could usefully be improved or changed, it seemed desirable to obtain information on such things as attitudes, aspects of general knowledge of pesticides, sources of knowledge, etc. For purposes of analysis, the original questionnaire has been broken in areas as follows:

- a. General background - Questions 2, 3 and the Supplement.

b. Sources of information on pesticides -

general - Questions 12, 13, 14/15

disposal of waste pesticides and containers - Questions 12,  
18, 19

storage of pesticides - Questions 16, 17

treatment of pesticide poisoning - Question 8

c. Farmers' attitudes towards pesticides - Questions 1, 32, 33, 34

d. Farmers' knowledge of pesticides -

undesirable effects associated with pesticide use -  
Questions 5, 6

poisoning by pesticides - Questions 11, 10.b.

legal aspects of disposal - Questions 28, 29

disposal of pesticides and containers - Question 22, 25

storage of pesticides - Question 37

e. Farmers' behaviour -

method of poisoning treatment - Question 7, 9, 10.a.

methods of disposal - Questions 20, 21, 23, 24, 30, 31, 36, 38

methods of storage - Question 35

perceptions of need for help with disposal - Question 26, 27

f. Magnitude and nature of disposal problem -

quantity of waste pesticide generated or disposed - Question 21

quantity of pesticide containers generated or disposed -  
Question 4.

incidence of poisoning - Question 9, 10.a.

#### 4.1 Background information

The data sought in Questions 2 and 3, and in the Supplement have little intrinsic value, and were gathered mainly for statistical reasons.

<p>Q.2. Into which decade does your age fall?</p> <table><tr><td>Teens</td><td><input type="checkbox"/></td></tr><tr><td>Twenties</td><td><input type="checkbox"/></td></tr><tr><td>Thirties</td><td><input type="checkbox"/></td></tr><tr><td>Forties</td><td><input type="checkbox"/></td></tr><tr><td>Fifties</td><td><input type="checkbox"/></td></tr><tr><td>Sixties or more</td><td><input type="checkbox"/></td></tr></table>		Teens	<input type="checkbox"/>	Twenties	<input type="checkbox"/>	Thirties	<input type="checkbox"/>	Forties	<input type="checkbox"/>	Fifties	<input type="checkbox"/>	Sixties or more	<input type="checkbox"/>	<p>Q.2.: No problems were experienced, except for the occasional answer relating to year of birth, rather than age.</p>												
Teens	<input type="checkbox"/>																									
Twenties	<input type="checkbox"/>																									
Thirties	<input type="checkbox"/>																									
Forties	<input type="checkbox"/>																									
Fifties	<input type="checkbox"/>																									
Sixties or more	<input type="checkbox"/>																									
<p>Q.3. Which of the following lives on this property:</p> <table><tr><td>Child or children aged six years or less</td><td><input type="checkbox"/></td></tr><tr><td>Free-roaming pets (e.g. dog, cat, but not budgie, fish etc.)</td><td><input type="checkbox"/></td></tr><tr><td>Working dogs</td><td><input type="checkbox"/></td></tr><tr><td>Commercial or other livestock including horses, goats etc.</td><td><input type="checkbox"/></td></tr></table>		Child or children aged six years or less	<input type="checkbox"/>	Free-roaming pets (e.g. dog, cat, but not budgie, fish etc.)	<input type="checkbox"/>	Working dogs	<input type="checkbox"/>	Commercial or other livestock including horses, goats etc.	<input type="checkbox"/>	<p>Q.3.: Sometimes more than one home was found on a property, and these were included in this question.</p>																
Child or children aged six years or less	<input type="checkbox"/>																									
Free-roaming pets (e.g. dog, cat, but not budgie, fish etc.)	<input type="checkbox"/>																									
Working dogs	<input type="checkbox"/>																									
Commercial or other livestock including horses, goats etc.	<input type="checkbox"/>																									
Suppl.	<table><tr><td>Impression of house</td><td>VG</td><td>G</td><td>Fair</td><td>B</td><td>VB</td></tr><tr><td>Impression of farm</td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>Education?</td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>Other?</td><td></td><td></td><td></td><td></td><td></td></tr></table>	Impression of house	VG	G	Fair	B	VB	Impression of farm						Education?						Other?						<p>Suppl.: This information was sought as optional background and possible explanation of behaviour. (Symbols stand for <u>very good</u> through to <u>very bad</u>.)</p>
Impression of house	VG	G	Fair	B	VB																					
Impression of farm																										
Education?																										
Other?																										

#### 4.2 Sources of information

Both general sources of information on pesticides, and specific sources relating to aspects of disposal and storage, and to treatment of poisoning were explored. The aims were to determine which sources of information are most frequently utilized by the farmer, which sources he finds most credible, and finally, whether in fact he was actually exposed to some sources claimed.

4.2.1 General sources of information reaching the farmer are of interest to any people or organizations wishing to communicate information to him (e.g., Government departments, the agricultural and veterinary chemical industry and others). It is important also, to be able to make some assessment of actual and perceived quality of information.

Q.13. Probably, you have a number of sources of technical information on pesticides. Could you please look at this list and tell me which is your most important source, and which your second most important? (Show subject list)

- a. Tasmanian Journal of Agriculture ☐
- b. other journals or publications ☐
- c. officers of the Department of Agriculture ☐
- d. other farmers ☐
- e. farmer organizations ☐
- f. representatives from the companies making the pesticides ☐
- g. literature or 'paper' advertising (i.e. not radio or T.V.) from the makers of the pesticides ☐
- h. personnel of agricultural chemical retailers or distributors ☐
- i. television ☐
- j. radio ☐
- k. University of Tasmania, or other university ☐
- l. other. Specify: ☐

Q.13.: Answers to this question were obtained by showing the farmer the adjacent list in a small display folder designed for the purpose. The 'most important' source scored 2, and the 'second most important', 1. Where the farmer could not separate sources, the score was halved. At the time of compilation, the list was deemed complete. However, in the course of interviewing, it became apparent that the package label should have been

included on the list. Whilst this may have affected validity of the result - the option of 'other' was given - in practical terms little was lost. The reason is that all pesticide users receive a package label, and the label is an unlikely key source of information in any education campaign.

Q.14. Are you, in general, satisfied with the quality and/or quantity of the technical information on pesticides, which you receive overall?

- No ☐ - proceed to Q.15.
- Yes ☐ - proceed to Q.16.

Q.14: Self-explanatory.

Q.15. What aspects of the quantity and/or quality of your information on technical aspects of pesticides is unsatisfactory?

Quality?  
Quantity?

What suggestions do you have for improving its quantity and/or quality?

Q.15.: This question is of general interest, but perceived deficiencies in the area of disposal and storage are of particular interest.

Overall, the most important source of information was the officers of the Department of Agriculture who scored 89 points out of a possible 200. Given that there were at least twelve sources of information, this score indicates that Departmental officers have a central role in providing information on pesticides. It is of note that this result was the same for nine of the 13 Department-designated districts, the lowest rating having been third.

Source	Score
Department of Agriculture officers	89
Distributor, retailer, etc.	57½
Manufacturer representatives	35
Journals and publications other than Tasmanian Journal of Agriculture	23
Other farmers	22½
Tasmanian Journal of Agriculture	16
Advertisements in literature, pamphlets, etc.	10½
Label on the container	10
Agricultural consultant	4
Cannery, food processor	3
Contractor (who carries out the spraying)	3
Farmer organizations	3
Television	1
Radio	1
University of Tasmania	1
Department of Agriculture district newsletter	1

Table 12 : Relative importance of different information sources.

Farmers' perceptions of the overall quality or availability of pesticide technical information which reached them was varied, and 43% expressed dissatisfaction. It is important to note that expression of dissatisfaction is not generally an indication that information does not exist - merely that the farmer may not have adequate motivation or resources, usually the former - to find the information. This open-ended question (Q.15.) generated a wide variety of complaints, and practical aspects of pesticide use were the basis of most. For example: What is the correct timing of pesticide application? How appropriate are specific application instructions for this (particular) area? Metric units still cause problems in mixing pesticides. Where are there informed and unbiased sources of information on the best pesticide for a given situation?



Many of these responses showed the farmer to be ill-informed and sometimes completely wrong in his impressions of information sources.

The impressions of information in the area of central interest, disposal, storage, and undesirable effects are now considered. The perceived shortcomings of information (not) received did not in one case relate to aspects of disposal or storage. In fact, the single most common general complaint was about the lack of information on potential harm to humans, and the unknown effects which pesticides cause<sup>7</sup>. More specifically, the perceived information inadequacies in this area related to the nature of the unintended effects of pesticides, and to the available information on the long-term effects of pesticides. For example, the pre-marketing assessment of these effects was seen as too short because unexpected deleterious effects become apparent after years of use. A number of farmers commented adversely on the amount of general information available on safety aspects of pesticides, and specifically, inadequate information on first-aid received comment<sup>8</sup>. Comment on labels was frequent (suggesting that they are perhaps a more important source of information than the survey indicated), and the proneness of labels to damage was criticized. Dissatisfaction with labels related also to confusion about the meaning of scheduling symbols (usually S5, S6, and S7; "what do they mean?", "do they overstate potential dangers?"<sup>9</sup>) to the over-emphasis of the scientific and under-emphasis of the practical<sup>10</sup>, and to inadequate information on antidotes for poisoning cases<sup>11</sup>. (These points came up both generally and in the specific context of labels.) In more general vein, the difficulty of access to information was singled out as a problem, and on a number of occasions, the accuracy of information coming from manufacturers was questioned.

One of the more frequently suggested solutions to these problems was the publication, preferably by independent bodies, of booklets which describe the method of use, the dangers and the necessary safety precautions, for specific products. More generally, information on the principles of pesticide use and the attendant

hazards to man and the natural environment was seen as useful. (The first of these suggestions represents little advance on existing labels; the second suggestion is for information already existing, but perhaps not in form suitable for the farmer.)

4.2.2 Disposal of waste pesticides and containers: the three questions below were aimed at finding where, if anywhere, the farmer had heard, or seen information on correct disposal methods.

Q.12. The State Department of Agriculture publishes quarterly its Journal of Agriculture. Irrespective of where you have obtained it from, and whether or not you read it, have you been, since the beginning of 1975,

- a. a regular receiver of the Journal (i.e. all editions) ☐  
 or, b. an occasional receiver of the Journal ☐  
 or, c. a non-receiver of the Journal ☐  
 or, d. other. Specify. ☐

Q.18. Can you recall having seen or heard information on the correct method of disposing of unwanted pesticides or pesticide containers?

- No ☐ - proceed to Q.20.  
 Yes ☐ - proceed to Q.19.

Q.19. Did you hear or see about the correct method of disposal. (Show subject list)

- a. in a journal or publication?  
 b. on radio or television?  
 c. from your agricultural chemical supplier?  
 d. from other farmers?  
 e. from pesticide manufacturers?  
 f. I'm not sure where from  
 g. other. Specify:

Q.12.: There are only two known written sources of correct information on disposal for Tasmanian farmers. One is the Tasmanian Journal of Agriculture published in May, 1975.

Q.18.: One possible fault with this question is the implicit assumption that the farmer can judge 'correct' information. However, the author has not encountered any incorrect information, merely incomplete information.

Q.19.: Of these different sources of information, only the agricultural chemical supplier was in any way verifiable, because only two documents are in any way likely to have been seen by Tasmanian farmers: the article mentioned above in the Tasmanian Journal of Agriculture<sup>12</sup>.

and the chart produced by the Agricultural and Veterinary Chemical Association<sup>13</sup>. The latter could have reached the farmer via the supplier, the pesticide manufacturer or the Department of Agriculture, and it is quite likely that radio programmes would have mentioned disposal at some time.

Regular readership at some stage of the Tasmanian Journal of Agriculture was claimed by 66% of interviewees. Overall, 55% claim to have been subscribers during 1975 and have therefore, in theory, been exposed to correct information on disposal technique. However, when the general question on seeing or hearing information on disposal was asked (Question 18), only 49% responded positively, irrespective of source. The sources claimed by these 49 subjects are summarized in the following table:

Source	Frequency of mention*
manufacturer	25
journal or publication	13
Department of Agriculture - officers	5
radio, television	3
distributor, retailer	2
other farmers	1
father	1
not sure	7

\* Farmers could name more than one source.

Table 13 : Sources of information on disposal technique

The vast majority naming the manufacturer as the main source of this information were in fact referring to the label, something already found to be a poor source of information on disposal (see page 56 ). However, labels have one positive feature as a source of disposal information: they do at least raise the issue of disposal. Of the 13 subjects nominating 'journals or publications' as a source, three specified Department of Agriculture District Newsletters, which, with only one exception among the 13 districts, was an incomplete source of information. The balance of ten probably all referred to the Journal, but three of those were disqualified or doubtful on the basis of their period of subscription. References to radio and television almost certainly related to talks given by Department officers. This means that overall, the total information from the Department is probably second to the 'manufacturer' source, but unfortunately, the questionnaire format does not permit a definitive statement. Another drawback to this question is that quality of the information allegedly received can be assessed only approximately. In general, however, at best it would only have been adequate.

4.2.3 Storage of pesticides: sources of information were assessed in much the same way as for disposal, as above.

<p>Q.16. Can you recall having seen or heard information on the correct method of storing your pesticides</p> <p style="text-align: center;"> <input type="checkbox"/> No      - proceed to Q.18.  <input type="checkbox"/> Yes     - proceed to Q.17.         </p> <hr/> <p>Q.17. Did you hear or see about the correct storage method. (Show subject list)</p> <table style="width: 100%;"> <tr> <td style="width: 80%;">a. in a journal or publication?</td> <td style="width: 20%; text-align: center;"><input type="checkbox"/></td> </tr> <tr> <td>b. on radio or television?</td> <td style="text-align: center;"><input type="checkbox"/></td> </tr> <tr> <td>c. from your agricultural chemical supplier?</td> <td style="text-align: center;"><input type="checkbox"/></td> </tr> <tr> <td>d. from other farmers?</td> <td style="text-align: center;"><input type="checkbox"/></td> </tr> <tr> <td>e. from pesticide manufacturers?</td> <td style="text-align: center;"><input type="checkbox"/></td> </tr> <tr> <td>f. I'm not sure where from</td> <td style="text-align: center;"><input type="checkbox"/></td> </tr> <tr> <td>g. other. Specify:</td> <td style="text-align: center;"><input type="checkbox"/></td> </tr> </table>	a. in a journal or publication?	<input type="checkbox"/>	b. on radio or television?	<input type="checkbox"/>	c. from your agricultural chemical supplier?	<input type="checkbox"/>	d. from other farmers?	<input type="checkbox"/>	e. from pesticide manufacturers?	<input type="checkbox"/>	f. I'm not sure where from	<input type="checkbox"/>	g. other. Specify:	<input type="checkbox"/>	<p>Q.16., 17.: The questions have the same weaknesses as those above: difficulty of validation of farmer response, and difficulty of assessment of quality of information received. Implications of the word 'correct' in the question are the same also.</p>
a. in a journal or publication?	<input type="checkbox"/>														
b. on radio or television?	<input type="checkbox"/>														
c. from your agricultural chemical supplier?	<input type="checkbox"/>														
d. from other farmers?	<input type="checkbox"/>														
e. from pesticide manufacturers?	<input type="checkbox"/>														
f. I'm not sure where from	<input type="checkbox"/>														
g. other. Specify:	<input type="checkbox"/>														

The proportion of interviewees claiming to have seen or heard information on the correct method of storage, 57%, was 8% more than for information on disposal. The sources were similar, and manufacturers or the label were again the most frequently mentioned, followed by journals and publications, and then Departmental officers. Full details were as follows:

Source	Frequency of mention*
manufacturer	29
journals or publications	11
Department of Agriculture - officers	10
distributors, retailers	6
radio or television	5
father	3
son	1
Tasmanian Farmers' Federation	1
Department of Labour and Industry	1
not sure	6

\* Farmers could nominate more than one source.

Table 14 : Sources of information on storage method.

As mentioned earlier, the package label is more explicit about storage than it is about disposal, and in this case is an acceptable source of information. Of the remaining sources named, Departmental officers and the Department of Labour and Industry (who had a 'travelling lecturer' on farm safety based in Burnie) could be regarded as adequate sources. Other sources may have been adequate, but individual assessment of farmers would have been necessary to establish this.

4.2.4 Treatment of poisoning: knowledge of treatment techniques, or of sources of information on treatment are a desirable part of every farmer's intellectual resources, particularly if he handles pesticides.

<p>Q.8. Do you know where you may obtain information on the treatment of cases of poisoning? (Subject <u>not</u> shown list)</p> <p>P.I.C. doctor hospital book chart pesticide package label other. Specify " Specify</p>	<p>Q.8.: Interviewees were not shown this list for obvious reasons. Whether reaction firstly, to this question, or secondly, to an actual emergency would be similar would vary from subject to subject. This question was put to only 94 subjects; where, in Q.6. (see p. ) the poisoning of humans by pesticides was considered impossible, there seemed no point in asking.</p>
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In particular, awareness of the existence of first aid information on package labels, and of the Poisons Information Centre located in Hobart (and in each State capital) was of interest. The information on the label is particularly important because, firstly, it is usually immediately at hand in the event of a mishap, and secondly, because the label describes treatment specific for the product and represents the best first aid information for lay persons available. Awareness of the Poisons Information Centre is important because, whether label information is at hand or not, the best source of advice is this Centre<sup>14</sup>.

Doctors were the most often named source of information on poisoning treatment. In fact, 96% of the 94 asked named the doctor, 54% the package label, 46% the hospital, and 38% the Poisons Information

Centre. The proportion of farmers who mentioned neither labels nor the Poisons Information Centre was 26%. Of those, only one did not mention the doctor or the hospital - arguably the next best sources. Details of the response are as follows:

Source	Frequency of Mention of Sources	
	Number	Per-cent
doctor	90	96
label	51	54
hospital	43	46
Poisons Information Centre	36	38
Department of Agriculture	23	24
pharmacist	18	19
district nurse	14	15
book (first aid or similar)	10	11
ambulance service	9	10
manufacturer	7	7
Police	5	5
University	5	5
first aid chart <sup>15</sup>	5	5
veterinarian	3	3
manufacturer's representative	1	1
distributor	1	1
Department of Labour and Industry	1	1

Table 15 : Chosen sources of information on poisoning treatment.

#### 4.3 Farmers' attitudes towards pesticides

This document considers different aspects of pesticide safety and the dangers which arise from their use. Whilst not directly related to the issues of disposal and storage, the responses to this brief attitude survey were interesting in their own right, and provided further background to matters raised elsewhere. This question (below) was the first in the

questionnaire, and it is possible that its general orientation may have had some influence on all responses which followed it.

<p>Q.1. Firstly, I would like to find out something about your general thoughts on pesticides, and so I'm going to read to you six separate statements. For each, could you indicate whether you strongly agree, agree, are uncertain or indifferent, disagree or strongly agree. Is that clear? (Show subject list of answers).</p>					
	Strongly agree	Agree	Uncertain/Indifferent	Disagree	Strongly disagree
a. Pesticides are essential for successful farming or production on my property.	47	46	4	3	0
b. There is nothing ethically wrong in using pesticides for their normal intended purpose.	18	69	8	5	0
c. It would be preferable not to have to use pesticides on this property.	43	45	1	6	4
d. In general, farmers do not use sufficient pesticides.	3	18	25	47	7
e. Pesticides have contributed significantly to the success of agriculture in Australia.	36	52	12	0	0
f. It would be preferable not to have to use pesticides on any property.	28	62	1	5	4
<p>Would you like to make any further comment on any of these statements?</p>					

Q.1.: Statements were devised by the author. Qualification of the subjects' response was frequent, and these were noted. In part b., the meaning of 'ethically' sometimes required explanation, and it seemed possible on a number of occasions that understanding of the word was feigned, or circumnavigated by giving a neutral response. For parts c. and f. the wording seemed occasionally to cause confusion, and the statement was repeated. Statement d. was worded so that thoughts, values, etc., consistent with early responses required a change of response from 'agree' to 'disagree' or vice-versa. This is a common ploy for discouraging (or detecting) the 'automatic' answer<sup>16</sup>. Part d. had two possible interpretations, one referring to economic consequences of pesticide under-use (intended), and the other, to use of under-strength, or unintended under-application (in relation to the spread of a pest, weed, etc.) of pesticide. Part e. caused some confusion at times because breadth of general knowledge of Australian agriculture seemed narrow sometimes.

The open-ended style of the six statements elicited a wide range of comments, the most common and most significant of which are recorded below.

Overall, there was 'strong agreement' or 'agreement' in 95% of farmers interviewed that pesticides are essential for successful farming or production, and none disagreed strongly with the statement. However, note must be made of five farmers who, at the time of initial telephone contact, claimed that they used no pesticide on their property (and who were therefore not interviewed). In four of these five instances (the fifth was not asked), responses to a question on the telephone suggested disagreement to some degree with the notion that pesticides were essential. If these four are taken into account, only 89% of farmers contacted could be described as agreeing with the statement.

Among the reasons given by the non-users for their belief, were uneconomic return from use<sup>17</sup>, "Dad didn't use them and I'm carrying on the tradition",

"one can get by without them", and the claim that pest problems are only minor, and management techniques are adequate to handle them. Those who believed that pesticides are essential, supported their views with comment on the work saved, on animal health problems (e.g., ectoparasites) remediable only by pesticide use, on the fact that some notifiable diseases of stock or infestations by noxious weeds must, by law, be treated using chemicals, and on the financial losses incurred if pesticides are not used. However, it was frequently noticeable that, even if a farmer held pesticides to be essential, he had reservations about their use. These reservations were sometimes expressed in a general way, sometimes related to specific products (such as 2,4,5-T) or product groups (such as organophosphorus compounds). A frequently made, but difficulty interpreted statement, was something like, "I use them only because I have to".

The ethics underlying the use of pesticides caused concern to only 5% of the sample, 87% having found no ethical objection to their use. Such a response among users was hardly surprising: firstly, particularly at the outset of a face-to-face questionnaire, admission to a significant compromise of personal principles is unlikely to be revealed to a stranger. Secondly, it is unlikely that many have seriously considered what they believe to be the inherent rights and wrongs of pesticide use, and this is borne out by comments which follow. Secondary comment revolved around such issues as indirect harm through residues or direct harm to non-target organisms including man and beneficial predators and parasites of pests, and the belief that registration of agricultural chemicals is granted before sufficient is known of unwanted effects (a comment based on the perceived harms caused by some older products such as DDT or 2,4,5-T). It was paradoxical that those having ethical objections to pesticides often made similar qualifying statements to those having no objections.

Expressions of preference to use, or not to use pesticides followed a similar bias to the preceding responses. Only 10% disagreed or disagreed strongly with the proposition that it would be preferable not to have to use pesticides on the property. Disagreement may be taken to mean that the perceived advantages of pesticide use outweigh the perceived disadvantages - if any. In other words, among the 45% agreeing with the statement and the 43% strongly agreeing, there are significant reservations, of some type, about their use. Among both classes of 'disagrees', the qualifying



comments did not always relate directly to the issue, and included statements about the basic nature of pesticides, and reference to lack of any realistic alternatives. Commercial aspects (i.e., profitability) were mentioned, and in one case, it was asserted that non-use of pesticides would be acceptable, if all farmers ceased using them. Those agreeing with the statement spoke of effects on non-target species, and of the costs of pesticides. The issue of costs is clearly a two-edged sword: whilst the money cost of pesticides is an understandable deterrent to use, the alternative cost in time (to achieve the same result in another way) cannot logically be presented in the negative light that some farmers did. (A superficial consideration of pre- and post-pesticide agriculture would highlight the amounts of time spent on manual control of pests, particularly weeds, or the amount of production lost because manual or similar approaches failed due to the magnitude of the job.) Perceived ignorance among pesticide scientists of the effects of pesticides in the environment and of the significance of their residues (now a less important issue, see Chapter 1) seemed to be a cause of unease among interviewees. The (paraphrased) statement, that, "Pesticides are a necessary evil", was heard on a number of occasions, but the disadvantages of use also received frequent airing, among them the damage done to pastures.

The last of the six statements was almost identical to that discussed immediately above; the only difference lay in the extent of pesticide use proposed. In the first case (part c.) the subject expressed a preference to use/not use pesticides on *his own* property; in the second case (part f.) a response to use/non-use on *all* properties was required. These two similar statements were deliberately separated in the question, and their purpose was to uncover the possible existence of an "I'm all right Jack," syndrome, i.e., an attitude which indicates acceptance of the positive results of the farmer's own pesticide use, but not the negative outcomes imposed by others' use. The author believes that the independent (and sometimes more) nature of the Australian farmer, as well as the existence of particular values held in the general community, justify the search for such possible attitudes. In fact, the responses of only three subjects suggested the existence of such attitudes. Overall, the response to the final statement was very similar to statement c., 90% showing 'agreement' or 'strong agreement'. However, approximately twice as many agreed as strongly agreed, whereas in the first statement of this

pair, numbers were roughly equal. Qualifying statements were again numerous and similar to the earlier statement. Predictably such problems as the spread of (ovine) lice and noxious weeds from neighbouring properties were raised, as also the problem of herbicide spray drift (which may severely damage some crops or flowers). Also mentioned was the geographically mobile problem of insecticide resistance which may arise from imprudent or unnecessarily frequent pesticide application.

The statement, 'In general farmers do not use sufficient pesticides' unfortunately, showed itself open to a number of interpretations. Agreement could indicate the belief that farmers use less pesticide per unit area, or, per unit of volume in the tank-mix than is recommended. It could also mean that the area treated with spray is insufficient to control the problem. 21% of interviewees agreed with the statement. Conversely, disagreement could indicate the belief that other farmers, neighbours included, are controlling their pest problems adequately with pesticides, or, that any more could lead to some type of undesirable result, or, that too much is being used already. A total of 54% fell into this category, and a further 25% were uncertain. This statement did not evoke the same free comment as others. More than one subject commented that cost prevents over-use of pesticides. The high 'uncertain' vote seemed to reflect an ignorance of the habits of other farmers in pesticide use.

The statement that pesticides have contributed significantly to the success of Australian agriculture, found agreement or strong agreement in 88% of interviewees (respectively 52% and 36%). The remaining 12% was an 'uncertain' vote, there being no dissent at all. Secondary comment was scarce, but in general, some importance was attributed to the input of pesticide into agriculture.

Late in the questionnaire, potential personal (as opposed to written, radio or television) influencers of attitudes were briefly sought.

<p>Q.32. Are you aware, among your neighbours, friends, family, community leaders, other people in your area, of any strongly held views on the use of pesticides in general?</p> <p style="text-align: center;">             No <input type="checkbox"/> - proceed to Q.35.              Yes <input type="checkbox"/> - proceed to Q.33, Q.34.         </p> <hr/> <p>Q.33. To which of the following groups does/do this person/people belong?</p> <table style="width: 100%; border: none;"> <tr> <td style="width: 80%;">Immediate family</td> <td style="width: 20%; text-align: center;"><input type="checkbox"/></td> </tr> <tr> <td>Relations</td> <td style="text-align: center;"><input type="checkbox"/></td> </tr> <tr> <td>Neighbour</td> <td style="text-align: center;"><input type="checkbox"/></td> </tr> <tr> <td>Member of organization. (e.g. Dept. Ag., F. &amp; G., conservation group etc.)</td> <td style="text-align: center;"><input type="checkbox"/></td> </tr> <tr> <td>Other. Specify:</td> <td style="text-align: center;"><input type="checkbox"/></td> </tr> </table> <hr/> <p>Q.34. What, briefly are their views?</p>	Immediate family	<input type="checkbox"/>	Relations	<input type="checkbox"/>	Neighbour	<input type="checkbox"/>	Member of organization. (e.g. Dept. Ag., F. & G., conservation group etc.)	<input type="checkbox"/>	Other. Specify:	<input type="checkbox"/>	<p>Q.32., 33., 34.: The questions are aimed at finding whether subjects were aware of any potential attitude influencers, and their identity.</p>
Immediate family	<input type="checkbox"/>										
Relations	<input type="checkbox"/>										
Neighbour	<input type="checkbox"/>										
Member of organization. (e.g. Dept. Ag., F. & G., conservation group etc.)	<input type="checkbox"/>										
Other. Specify:	<input type="checkbox"/>										

Only 20% of farmers interviewed claimed to be aware of any strong views on pesticides held in their family or community. The type of person who espoused these various strong views was most often neighbours, but of lesser and approximately equal numerical importance were family members, 'greenies', 'townies', and organic farmers. Because the nature of these views could be a factor in the formation of attitudes, brief comment is made here. The most commonly encountered view held by these third parties, was that pesticides in general are a bad thing, and should not be used at all. This general condemnatory view was held by 43% of the 26 reported third parties. A further 23% of these people had expressed concern over the use of 2,4,5-T (presumably related to the type of information emerging from the various enquiries being held in the United States, Australia and other countries at the time). Other objections allegedly expressed by these third parties referred to general deleterious effects in the environment, risks to humans and livestock, abuse of the need for general care in use of pesticides, spoilage of food, and others.

It has been mentioned that this assessment of attitudes was never intended to be detailed, but because the overall responses obtained were relatively decisive (the five predominantly 'agree' cases ranged between 93% and 87%, although the one preponderantly 'disagree' case rated 54%), some generalisation seems justified. The farmer seems to be placed in a situation of some conflict: on the one hand he concedes that agriculture owes much to the use of pesticides and that they are essential for successful farming. On the other hand, however, he would prefer not to see them used, even

though he has no ethical objection to them. The answers to Questions 5 and 6 immediately below offer some explanation for this conflict.

#### 4.4 Farmers' knowledge of pesticides

##### 4.4.1 Undesirable effects associated with pesticide use

Q.5. The farming community and the community at large hold a variety of opinions on pesticides. Overall, however, it seems clear that most people believe that correctly used pesticides have beneficial effects. Do you associate any actual or possible undesirable effects with the correct use of, or mere presence in containers on the farm, of pesticides? (Answer 'no', 'not sure', 'yes').

No	25
Not sure	4
Yes	71

Could you explain why you believe that, please?

Q.5.: It was intended that introductory wording to the question counteract any implications of the actual question. An introduction putting both sides may have been better. Use of the words 'correct' and 'correctly' occasionally required clarification, as meaning use within normal limits of care on the farm.

This word was originally included so that suicide or use of pesticides as baits would not be considered within the question. It was sometimes necessary, also, to point out that both of these questions relate to all farms, not only that of the subject.

Q.6. Do you believe that pesticides stored on farms, or in the course of normal preparation or use, could possibly lead to, or contribute directly to any of the following? Could you please answer with 'yes', 'not sure', 'no', but feel free to make any additional comment. (Repeat question) (Ask only the points not mentioned above in Q.5.)

	N	N/S	Y	
allergy in humans			✓	68
infection	✓			31
worsening pest problems			✓	33
poisoning of humans			✓	87
death of birds			✓	73
short-sightedness	✓			24
resistant pest species			✓	68
ecological disturbance or damage			✓	65
fire			✓	32
skin irritation			✓	90

Any comment:

Q.6.: This question is almost the same as Q.5. and was included in case the open-ended question preceding it did not elicit a response fully indicative of the farmer's knowledge. The words '..... could possibly lead to ....' required emphasis when asking the question. The questions were selected because they covered a variety of aspects of pesticide effects, and because the answers seemed clearly 'yes' or 'no'. The 'not sure' option was included to minimise guessing.

The two items 'infection' and 'short-

sightedness' were included as deliberately wrong answers principally to keep the subject alert.

Some problems did arise. Firstly, 'poisoning of humans' seemed sometimes to be interpreted as meaning 'death of humans', which was not intended. Rather, a variety of effects up to and including death, was meant. Secondly, for obscure reasons, some seemed to give their answers only in relation to stored pesticides. Thirdly, 'possibly' received two interpretations: either in the way intended, i.e., either, "it is possible, but will not necessarily lead to .....", or, in the sense of, "it is possible, but I'm not sure". In the latter case, the farmer does not have the knowledge to answer. Correct answers have been ticked and the number of correct answers given is shown.

Whilst it was of interest to find whether or not the farmers' perceptions of undesirable effects were correct, more important in this study are their *beliefs* of what is correct. As pointed out, the two questions ask for the same information - Question 5 in an open-ended way, and Question 6, in a closed way. In Question 5 the farmer *volunteers* his perceptions. The response had the weakness that it was a function of both knowledge and attitudes, whilst only an indication of knowledge was sought. The question had also a strength, that it was a statement of beliefs which could reasonably be expected to be consistent with a farmer's behaviour in relation to aspects of safety of pesticide use. Question 6 allowed the farmer's knowledge to be quantified because it was being tested directly against established fact.

Overall, Question 5 indicated that 25% of interviewees did not associate any undesirable effects with the use of pesticides, whilst 71% did, and 4% were unsure. The 25% was not asked to qualify its answer, but from the remaining 75%, a large and varied response was obtained. A notable feature of many of these responses was their incompleteness. Clearly, the question asks for qualification of the belief that pesticides cause undesirable effects, yet answers like those below were frequent:

"Children have access"

"Misuse occurs"

"It may drift onto the garden next door"

etc.

Clearly, such statements describe only situations from which undesirable effects may result, but they stop short of describing these actual effects. Such responses were sometimes probed, and the existence of further knowledge was sometimes established, sometimes not.

Responses to Question 5 were characterized also by considerable vagueness. For example, a response was frequently preceded by phrases such as, "I'm not quite sure, but I think that .....", or, "They [pesticides] do something to ..... , don't they?", etc.

Comment	Frequency of Mention
Humans adversely affected (headache, vomiting, illness, poisoning, death, etc.)	44
Other insects, predators and parasites affected	18
Farm animals adversely affected (sick, dead)	15
Children adversely affected	14
Water (streams, dams, etc.) contaminated	14
Birds affected or killed	13
General natural environment affected	13
Adverse reproductive and genetic effects (humans and other species)	13
Residues are found in food and food chains	13
Expressions of fear of the unknown effects, or of belief that there are effects, but not sure what	12
Worms affected or killed	9
Pastures retarded	8
Fish affected or killed	8
Bees affected or killed	7
Dermatitis or rashes of humans	7
Hypersensitivity or allergies in humans	6
Non-target species killed (broader than second-mentioned item above)	5
Drift arises from spraying	5
Soil microbes affected or killed	5
Residues build up in humans	5
Milk is downgraded or affected	4
Cancer is caused in humans	4
Residues occur (no qualification of residue type or location)	4
Gardens affected by drift	4
Wildlife killed	3
Crops retarded	3
Residues build up in soil	3
Resistance to pesticides develops in pests	3
Pollination (by bees) is reduced or ceases	2
Hospitalization of humans is necessary	2
Skin of livestock is burnt	2
Sterility of humans or livestock results	2
Withholding periods <sup>18</sup> are a nuisance	2
<p>A number of comments occurred only once, and to the use of pesticides were attributed sore hands, loss of skin, swellings, lung damage, sneezing, irrational thoughts, palpitations, numbness of feet, inflammation of mouth and throat, aches and pains, cardiac problems, a "bad back", epistaxis (bleeding nose), and possible gynaecological harm to young females (human). Other less personal results of pesticide use include generally adverse effects on the farm, a rise in the degree of weed infestation, harm to the atmosphere, and the incurring of costs. Finally, it is alleged that the use of pesticides leads to the use of more pesticides, and that pesticides tend to be leant on (i.e., replace management techniques).</p>	

Table 16 : Farmers' knowledge of undesirable effects of pesticides.

Because vagueness of response was so prevalent, it seemed that assessment would be more usefully based on awareness of risks, rather than on a crisp clear description of the actual risk or effect. By taking this approach, however, the author did not overlook the possibility, or more likely, the probability that vagueness may be traced back to incomplete farmer-knowledge. Nor may it be overlooked, that vagueness may reflect incompleteness of knowledge in the general field of pesticide science, let alone among farmers.

Table 16 on the previous page gives a detailed breakdown of the types and frequency of answers. Collectively, the knowledge of the less desirable consequences of pesticide use possessed by Tasmanian farmers is relatively complete, and this is an indication that all of this information has somehow been disseminated within the State. The individual, however, rarely responded with a relatively complete answer. In general, answers were usually rational, although phrases such as "deadly poisons", "cancer-causing ogres", "things which will kill us all off", etc., were forthcoming. In only a small number of instances were comments made which were clearly wrong, although it is difficult to assess the correctness of some of the once-mentioned effects found at the bottom of Table 16.

Not surprisingly, the analysis in Table 16 showed decidedly anthropocentric views among farmers. About 58% of comments referred either to harm directly to humans, or to effects influencing the running of the farm, or the state of the bank balance. The most common single response referred to the acute toxic effects on humans, such effects being described either quite non-specifically or as poisoning which produced anything from headache or vomiting through to death. However, specific maladies such as rashes, allergies, effects on the heart, etc., were also mentioned. Mention of two very specific effects of pesticides was made, namely epistaxis (bleeding nose) and lung damage, which, among pesticides, are caused only by bipyridyl herbicides - an indication that some depth of knowledge exists in some cases. Poisoning of children was a frequently named undesirable possible effect, and chronic or delayed effects such as cancer,

sterility, and effects on future generations were also claimed as possible results of correct pesticide use. The effect on future generations was mentioned also in the context of farm livestock.

The general issue of pesticide residues was raised in a number of ways. Residues, both in natural food chains and in the human body were seen as having, or possibly having a negative effect on humans, and residues in food and food chains rated high on the scale of frequency of mention. Residues were also mentioned in the context of soil build up, and of the unfavourable outcomes (mainly financial) associated with residue-containing milk.

Undesirable effects in the natural environment were seen by farmers in terms of kills of, or damage to birds, fish, bees, worms, wild animals and soil microbes. Less specific comments were made about effects on nature as a whole and on non-target species. Open-ended comments about contamination of water, and drift from spraying were recorded.

The undesirable effects believed to affect the farmers' income were an area of expected comment. Among the points raised were retardation of crop and pasture growth by herbicides, potential ill-effects (including death) among commercial livestock, rejection of milk containing high pesticide residues, and the problem of development of resistance to pesticides. Mentioned only once were tainting of foodstuffs, the killing of seed stored near phenoxyacetic herbicides, and increasing pest problems after prolonged use of pesticides. Whilst all of these points have some basis in fact, they are incomplete because they overlook the alternatives facing the farmer if he used no pesticide.

Answers to Question 6 gave a better idea of the individual's knowledge of potential undesirable effects. The average score, out of a possible 10, was 5.6 overall. The range of scores extended from 0 (once) to 10 (twice). The two questions which were best answered related to adverse effects on humans, and the two worst answered, also related to effects on humans. In the latter case, however,



many 'not sure' answers were given. It is possible to make some generalized conclusion about weaknesses in the farmer's knowledge in this area by referring to the scores shown in the box above on Page 19. Notable was the fact that the average score of farmers claiming no harm in Question 5 was 4.7 - lower than the 6.0 of the others. Another point worth comment was the low score on the question relating to flammability of pesticides - a hazard which is clearly highlighted on labels of flammable products. Finally, the low score for the 'bogus' question on pesticides as a direct cause of infection suggested a lack, or very hazy knowledge of the fundamental properties of pesticides.

4.4.2 Poisoning by pesticides: in considering the whole question of pesticide disposal and storage by the Tasmanian farmer, it was necessary to look at the possible consequences of less than perfect practice. One aspect of this was, firstly, an assessment of the frequency of poisoning cases of humans or livestock, and also some definition of the genesis of these poisonings. Secondly, having only incomplete knowledge of the problem of poisoning - if in fact there is one - before the survey, particularly where livestock were involved, it seemed worthwhile to consider the farmer's ability to cope with such an occurrence. However, it seemed rather pointless to assess this ability without knowing whether the farmer could recognize a case of poisoning; thus, an assessment also of ability to recognize symptoms was carried out.

Assessment of farmers' knowledge of poisoning was not as thorough as for knowledge of disposal and storage. Knowledge of poisoning symptoms was assessed in all cases, and assessment of knowledge of treatment was based either on the action taken in an actual case, or on the action that would have been taken, i.e., either knowledge or behaviour was tested, but not both.

# A. Symptoms of poisoning

Q.11. Poisoning by pesticides can produce a variety of different signs or symptoms in the person poisoned. Could you name as many signs or symptoms as you can which could indicate that a person has been poisoned by pesticides? In other words, what might a person complain about, or what things could you observe about him, if he were poisoned?

Q.11.: Assessment of a farmer's knowledge was carried out by comparing the answer with a list of all symptoms of pesticide poisoning noted by Dreisbach<sup>19</sup>.

Beyond this, additional points which were commonsense or logical extensions of this list, were accepted. Incorrect answers scored -1, vague answers 0, and correct answers +1. The list of symptoms in Table 17 below mentions no symptom which a farmer could not describe in one way or another.

Abdominal/stomach cramps/pains	Liver - symptoms of damage
Back - pain	Lung - symptoms of damage
Bleeding - internal	Lung - chemical pneumonia
Blood pressure - fall	Mouth/throat - sore
Coma	Mouth/throat - numb
Confusion	Mucous membranes - irritation
Control loss - muscle	Muscle - tremor, twitch
Control loss - bowel	Muscle - weakness
Convulsion	Nervousness
Diarrhoea	Nose - bleed
Dizziness	Nose - running
Drooling	Nose - stuffy
Exhaustion	Restlessness
Eyes - blurred vision	Shakiness
Eyes - double vision	Skin - irritation
Eyes - inflammation	Skin - burning, blistering
Eyes - pinpoint pupils	Skin - allergy, inflammation
Eyes - watering	Stimulation, excitement
Face - paralysis	Sweat - hot/fever
Face - tingling	Sweat - cold
Fingers - tingling	Tachycardia
Fits	Thirst
Headache	Tongue - tingling
Kidney - symptom of damage	Vomiting
Lips - tingling	Weight loss

Table 17 : Symptoms of pesticide poisoning<sup>20</sup>.

The average score obtained was marginally more than 3, out of a theoretical 50, and the range of scores was from 0 to 9. Whilst even the best of these do not compare well with the maximum, such low scores do not indicate that the farmers' ability to recognize symptoms was uselessly low. Even

recognition or naming of only one symptom indicated the ability to detect something that was amiss. However, relating a small number of symptoms to the cause may be difficult, particularly where the two are temporally separated. Relatively specific symptoms such as pin-point pupils, muscle tremor, tachycardia were rarely mentioned as symptoms. Not unimportant in this context is the practice which the livestock producer and dairy farmer has in diagnosis of ill-health among his stock.

The most commonly suggested symptoms, in order of frequency, were vomiting or nausea (50% of interviewees), headache (35%), dizziness (26%), abdominal or stomach cramps or pain (22%), and skin irritation (16%). Overall, 29 of the more than 50 acceptable answers were mentioned at least once. Frequency of scores was as follows:

Score	Frequency	Score	Frequency
0	13	5	10
1	9	6	6
2	21	7	1
3	16	8	3
4	20	9	1

Table 18 : Frequency table of scores and correct symptoms of pesticide poisoning given by farmers.

Clearly, the higher the score, the more likely it is that a farmer will recognize a case of poisoning, and equally important in a case of acute poisoning, the sooner he will recognize it.

*B. Action in a case of poisoning*

Q.10.b. What action would you take in the case of human poisoning by pesticide?

Q.10.b.: An actual case of poisoning and a discussion of a case of poisoning are two very different situations. Whether the reality of an actual case would help or hinder a person's reactions would vary enormously. This question then, only tested the interviewee's knowledge, not the likelihood of a favourable treatment.

Responses to this question, as in Question 11., were difficult to assess quantitatively. For example, it is difficult to reject as not entirely correct (and probably effective) the response, "I'd call the doctor", and in some cases - perhaps even the majority - because of the relative proximity of the local medico, hospital, district nurse, or veterinary practitioner, this is the best recourse. But such answers, however practical and successful in the approach they suggest, gave no indication of the respondents' knowledge or lack of knowledge of treatment technique. Whilst this casts some doubt on the worth of results described below, this finding of dependence on doctors, etc., could only have been revealed by survey.

Contact in one way or another with a doctor, district nurse, hospital or Poisons Information Centre was suggested by 90% of respondents as at least one 'method' of treatment. Resort to the label or other literature was mentioned by 40% of interviewees, and only 35% volunteered some form of treatment which they would instigate themselves. It should be mentioned that some of the treatment regimes suggested by this 35% would not always enhance survival chances of the patient. To suggest that 10%, or maybe even only 5% of farmers interviewed could handle a case of poisoning by pesticide without reference to medical or similar personnel, or to literature (other than labels) would be optimistic. The low frequency of mention of the Poisons Information Centre (5%), arguably the best source of advice in such circumstances, was noteworthy. Perhaps the most positive aspect of the interviewees' collective knowledge, was the appreciation of the element of urgency in poisoning cases.

4.4.3 Legal aspects of disposal: knowledge of legal aspects of disposal were examined in order to determine whether legal constraints influenced actual disposal methods.

Q.28. Do you know of any legal restriction relating to the fate of pesticide containers or unwanted pesticides?

No ☐ - proceed to Q.30.  
Yes ☐ - proceed to Q.29.

Q.29. Could you describe, very briefly, the laws which you believe to exist?

Q.28., 29.: No comment.

Overall, 17 farmers claimed knowledge of legal restrictions, but of those, only one was able to describe in any way the fundamental philosophy of the law as described in Chapter 3. It may be safely concluded that the law is of little consequence in determining method of pesticide or container disposal.

#### 4.4.4 Disposal of pesticides and containers

Q.22. Someone says to you, "Your method of handling these unwanted pesticides has both good and bad points." Is that person right, or wrong, or partly right and partly wrong? Why?

Q.25. Someone says to you, "Your method of handling empty pesticide containers has both good and bad points." Is this person right, or wrong, or partly right and partly wrong? Why?

Q.22., 25.: From the outset the wording shown here was supplemented with the question, "In other words, how do you see the good points and the bad points of your disposal technique, or is it all good, or all

bad?" This basic approach of self-assessment was utilized, firstly, to instil into the question some interest and immediate relevance, and secondly, to avoid the dryness and perhaps threat of an examination-like question, "How should you .....?" It was intended that this format should elicit a comparison of the farmer's actual practices with what he knows to be correct practice, and at times prompting was found necessary. Because this format was used, it was possible only to ask the question of those who had actually disposed of pesticide or containers. In practice, only one subject was not assessed for container disposal, but for pesticide disposal, only 31 could be assessed.

The method of assessment used is described below, and this method was used to assess both knowledge and practice of pesticide and container disposal.

In both cases, pesticides and containers, a series of questions was applied to the notes taken at the time of interview or inspection. The score is shown with a 'yes' (Y), or 'no' (N), and a high score indicates better knowledge or practice. Again, the open-ended style of the question generated a wide variety of types of answers, and some flexibility of assessment was necessary. However, the rules or questions below were generally followed relatively closely. Assessment of knowledge sometimes required addition or subtraction of bonus or penalty points to allow for correct (and significant) or incorrect comment not covered directly by the scoring system. In a small number of cases, it was not possible to see disposal sites because they were some distance (and time) away, and in these cases, assessment was done by questioning. In a few other cases, knowledge was not assessed at all, and allowance is made for this in the statistical calculations and comments below. It should be noted that the questions below are for assessment of practice; knowledge assessment was on the basis of *mention* of each of the points raised.

The basis for assessment of subjects was the guidelines issued by the Department of Primary Industry<sup>21</sup> and by AVCA<sup>22</sup>.

**Waste pesticides:** where a farmer had adopted more than one method of disposal, each was assessed, and the farmer given an average score.

- a. did the farmer make a positive effort to dispose? (Y, 1; N, 0). Even if the method was wrong, a conscious effort to dispose, rather than accumulate, deserved recognition. In assessment of knowledge, the point was almost assured.
- b. did the pesticide finish in a hole (Y, 1; N, 0) or in a municipal tip (Y, 1; N, 0)? If in a tip, the arbitrary assumption was made that the farmer chose to do this in order that all points below (c. to h.) were complied with. This assumption may be disputable, but it seemed reasonable to assume that if a farmer made sufficient effort to take wastes to a tip, he was concerned, at least, about the potential dangers of on-farm disposal or non-disposal. It seems reasonable also for the farmer to assume (rightly or wrongly), that disposal at a municipal dump would be without sequelae. If the farmer disposed on the farm, or elsewhere, he was further assessed, as below.
- c. did the farmer put lime in the hole with the pesticide? (Y, 1; N, 0).
- d. did the farmer burn the pesticide in the hole? (Y, 0; N, 1)
- e. did the farmer cover the pesticide? (Y, 1; N, 0)
- f. was the disposal site at least 500 m from the home? (Y, 1; N, 0). An arbitrary decision was again necessary on acceptable and unacceptable distance. The main considerations were assumed radius of immediate movement around the home of small children and pets.
- g. was the disposal site effectively protected from - children (Y, 1; N, 0); livestock or domestic animals (Y, 1; N, 0); or wildlife (Y, 1; N, 0)? Fences and other barriers were considered.
- h. was the disposal site more than 50 m from a body of free water? (Y, 1; N, 0). The arbitrary decision of 50 m considered dilution which would occur by seepage movement or surface movement, as well as time factors involved (which would promote degradation). Novak et al<sup>23</sup> suggested 30 m.

The maximum score was 10 for both knowledge and practice of disposal.

**Containers:** in general, the introductory comments above apply.

- a. did the farmer make a positive effort? (Y, 1; N, 0). Comment above under a. applies.
- b. was the container decontaminated immediately after use? Metal container, rinsed or burnt (Y, 1; N, 0); burnable containers, burnt (Y, 1; N, 0). Rinsing once with water, although less than recommended by the Department of Primary Industry<sup>24</sup> or AVCA<sup>25</sup>, was accepted as adequate. A total of 1 point could be earned in this question, at the author's discretion.

- c. between the time of emptying and of final disposal, were containers kept in a place secure from, or in a way harmless to children, animals, etc.? (Y, 1; N, 0). One point in this question was automatic if a point was gained in b.
- d. what was the interval between emptying and final disposal? No behavioural mark was allocated for this question, but the estimated interval was noted. A mark was awarded in knowledge assessment if the subject suggested that this time interval should be short.
- e. did the farmer re-use empty containers? Never (Y, 1); sometimes, but in an acceptable way (see below) (Y, 0); or, in an unacceptable way (Y, -1).
- f. was the end-point of disposal a hole (Y, 1; N, 0) or a municipal tip (Y, 1; N, 0)? Where a tip was the final resting point, for the same reasons as outlined above (Waste pesticides, b.), full marks were awarded for all subsequent questions (g. to k.). Where the disposal site was on the farm, assessment continued as below. Except for incineration, no other disposal site beside the farm and tip was encountered.
- g. were the containers reaching the disposal site holed and/or bashed? (Y, 1; N, 0).
- h. were containers reaching the disposal site covered and/or burnt? (Y, 1; N, 0).
- i. was the distance of the disposal site at least 500 m from the home? (Y, 1; N, 0). Considerations were the same, as for waste pesticides, as above.
- j. were the disposed containers made inaccessible to - children (Y, 1; N, 0); livestock or domestic animals (Y, 1; N, 0); or, wildlife (Y, 1; N, 0)? Considerations as above.
- k. was the distance of the disposal site from a body of free water - less than 10 m (Y, -1); between 10 m and 50 m (Y, 0); or, more than 50 m (Y, 1)? Assessment of the distance from water of disposed pesticide and disposed containers was different. There are two reasons for this: firstly, the likelihood of stream contamination is far higher from containers because pesticide cannot disperse from them (pesticide waste soaks into the ground), and secondly, because containers were dumped near to watercourses, etc., without any further attention.

Maximum score was 11 for practice, and 12 for knowledge.

Knowledge of correct pesticide disposal technique proved to be very rudimentary among the 31 farmers who had disposed of pesticide. Approximately 11% (of the 31) suggested that a pit or the local tip would be appropriate, and only 50% suggested that something (as opposed to nothing) should be done. Only one individual (3%) among the 31 suggested that lime should be added to the disposed pesticide, and only one (3%) suggested that burning was not

appropriate as a method of disposal. That the disposed pesticide should be covered was mentioned by only three (10%) farmers, and the advisability of disposing some distance from the home did not occur to any. However, the necessity to exclude children, livestock and wildlife from the disposal site was recognized by twelve (39%), thirteen (42%) and eleven (35%) individuals, respectively. Overall, the average score of farmers was a modest 25% (or 2.47 of a possible 10).

Knowledge of container disposal, assessed in 99 farmers\*, was better than that of pesticide disposal, although an average score of 39% (or 4.66 of a possible 12) could scarcely be called favourable. Less than a quarter (22%) considered decontamination of containers a part of the disposal process, and only 6% referred to the issue of security between the acts of emptying and of final disposal. Minimization of the interval between the emptying of a container and its final disposal was mentioned by 37% of farmers interviewed, but the matter of container re-use which was mentioned by 20% of interviewees, showed only 11% to be against re-use of any kind. Burial in a pit or removal to a tip was mentioned by a surprisingly low 13% of subjects, and only 8% referred to holing and bashing. Disposal at a site which was away from the home, was considered by only 4% to be an issue, but separation from water, by 25%. Covering or burning of the containers was considered by 32% of subjects to be part of the disposal process, and inaccessibility of disposed containers to children, stock and wildlife was mentioned by between 67% and 69% of subjects.

4.4.5 Storage of pesticides was assessed using the same style of question as for aspects of disposal, i.e., by self-assessment.

\* One farmer had just commenced farming his present property and had disposed of nothing.



Q.37. Someone says to you "The way in which you store your pesticides has both good and bad points." Is this person right, or wrong, or partly right and partly wrong? Why?

Q.37.: The comments made above about the general nature of Q.22 and Q.25., apply equally here. However, because

all 100 interviewees use pesticides, they also have a store of some sort on the farm, and so all could be assessed.

The actual assessment process for both knowledge and practice in storage was as follows.

The possible score for each of the questions below is given in brackets together with the answer, 'yes' (Y) or 'no' (N). A higher score indicates a better performance. Because the open-ended question generates a wide variety of answers, some flexibility in the assessment was necessary. However, the guidelines given below were followed relatively closely. Marks were allocated on an all-or-nothing basis, and again, bonus or penalty points were awarded for correct or incorrect comments made on matters not listed. The questions as set out below are aimed at assessment of practice; knowledge was assessed on the basis of *mention* of the issue raised in each question. Again, these assessments were made on the information contained in notes taken during interview or inspection.

The factual basis for assessment, against which comments or actions were judged, were Department of Primary Industries<sup>26</sup> and AVCA recommendations<sup>27</sup>.

- a. were the pesticides under cover (away from the weather)? (Y, 1; N, 0)
- b. were the pesticides stored in a specific cupboard or shed? (Y, 1; N, 0)
- c. were the pesticides stored behind a secure door? (Y, 1; N, 0)
- d. were the pesticides stored under lock and key? (Y, 1; N, 0)
- e. were the pesticides stored in a place secure from wildlife of all types? (Y, 1; N, 0). These three questions, c., d. and e., assess different degrees of security; respectively, from domestic and livestock, children and wildlife. (Birds, possums, etc., are difficult to exclude completely.)
- f. were the stored pesticides separated clearly from food, feed, water and fuel? (Y, 1; N, 0)
- g. was the store more than 20 m from the home? (Y, 1; N, 0). Twenty metres was arbitrarily accepted as the distance beyond which any pesticide vapours or pesticide spills would do inhabitants no harm.
- h. were all pesticides still stored in their original container? (Y, 1; N, 0)
- i. were all containers intact, with label, and sealed (all three)? (Y, 1; N, 0)
- j. were herbicides stored separately from all other pesticides? (Y, 1; N, 0)
- k. were only small quantities stored? Clearly, this question could not be answered for the assessment of behaviour because of the differences between property size, general pesticide usage, seasonality of use, etc. However, a mark was gained in the knowledge assessment if this aspect was mentioned.

Surprisingly, knowledge demonstrated was of an order similar to that of pesticide disposal - an average of 25% (or 2.76 of a possible 11). Most commonly mentioned (72%) points of knowledge were the need to keep pesticides behind a door and/or under lock and key. The fact that stored pesticides should be under cover was mentioned by 32% of subjects, and use of a specific shed or cupboard by 25%. Prevention of access to wildlife - not necessarily by use of locked doors - was considered by only 12% of interviewees as an issue, and adequate separation of storage from the home rated mention in only 7% of cases. Storage only in intact, sealed and labelled containers was referred to by 11% of farmers interviewed, and a mere 2% pointed to the recommendation for storage only in original containers. No mention was made of separation of herbicides from all other pesticides.

#### 4.5 Farmers' behaviour

Under this heading are described the actual practices of the farmers interviewed in relation to treatment of poisoning, disposal of pesticides and containers, and storage of pesticides.

4.5.1 Method of poisoning treatment and frequency of possession of the various aids for poisoning treatment were assessed closely together in the questionnaire.

None of the questions in this box were asked of the subject who indicated in Q.6. (see p.195) that poisoning of humans by pesticides was not possible. The total sample was 94, therefore.

Q.7. Imagine that you had a case of a pesticide poisoning - either an adult or a child - on this property. Do you keep anything around the home or farm which could help you treat this person correctly and efficiently?

No ☐  
Yes ☐

- what do you keep? (Do not probe until first reaction is complete).

[Where necessary: Literature?  
Medicaments?  
Apparatus?]

Q.7.: This question has the short-coming that recall prompted by the questionnaire may differ (in either direction) from that in an actual situation.

Q.9. Have there been any cases of poisoning by pesticides on this property

a. of humans? No ☐ - proceed to Q.10b.  
Yes ☐ - proceed to Q.10a.  
b. of animals? No ☐ - proceed to Q.10b.  
Yes ☐ - proceed to Q.10a,b.

Q.10. a. What action did you take?

Q.9.: This question probably has greater potential than any other in the questionnaire to show the farmer in a negligent light, and therefore also to elicit false answers. As far as could be judged, responses seemed truthful.

Overall, 55 (59%) of those asked had some form of poisoning aid at hand which they recognized as such. (It is assumed that the six who claimed poisoning by pesticides not to be possible, and who were not asked these questions, had nothing specific in their homes.) The remainder claimed to have none. The element of recognition of aids is quite important: it could be reasonably expected that all, or almost all households would hold milk or salt - both aids in the treatment of some pesticide poisonings. (In fact, salt is no longer recommended for inducing emesis, but there was no suggestion that any of the interviewees was aware of this change.) All households would have water on tap (somewhere), and use of water is commonly recommended in cases of poisonings. It is difficult to believe that the use of water for washing pesticide-contaminated skin would not occur to anyone involved, if not its use as a diluent of ingested pesticide. The table below indicates the frequency of mention of poisoning aids in the home or on the farm.

Item	Frequency of holding (%)
Label	30
First aid manual, literature, chart	28
Salt	15
Milk	11
First aid kit	9
Atropine	7
Water, tea, coffee	6
Ipecac	4
Calamine	1
Eggs	1

	Frequency of mention without actually holding (%)
Ipecac	11
Atropine	1

Table 19 : Frequency of recognition of poisoning aids held on the farm

Naturally, all who use pesticides also possess container labels which bear first aid instructions; the most commonly named aid, they were mentioned by only 28 (30%) interviewees (although 51 (54%) mentioned labels as a source of information in a case of poisoning in Question 8). Next most commonly mentioned was literature in the form of first aid or other books (25 mentions) and charts (3). Literature, in total, was mentioned by 30% of interviewees, but there was evidence that many of the first aid manuals were years old and, therefore, probably without information on many of the newer pesticide compounds. Furthermore, it was clear that many of the subjects would have difficulty in quickly locating these books so that they could respond with appropriate speed - having already forgotten or never known that the label is the best starting point. Salt was the next most commonly mentioned aid (15%), followed by milk (11%). This was followed by first aid kits (9%) but most stated either that these kits offered little of value for cases of poisoning, or they were not sure of its use in such a situation. Atropine<sup>28</sup> and Ipecac Syrup<sup>29</sup> were mentioned seven (7%) and four times (4%) respectively, and these two items in particular were of interest. A further ten interviewees mentioned atropine without actually having stock of it, and similarly, one further mention of Ipecac was made. Other recognized aids held even less frequently were water and calamine skin lotion.

Possession of atropine tablets and Ipecac Syrup has particular significance for three reasons. Its possession is a likely indication of at least a basic working knowledge of poisoning treatment. Further, atropine has no use to the farmer other than for the treatment of poisoning by organophosphorus or carbamate pesticides, and Ipecac no use other than as an emetic (for induction of vomiting after poison of almost any type that has been ingested). Stock of these on the farm indicated that the farmer (or his family) was prepared to go to some (little) trouble in order to ensure some degree of readiness in case of mishap of this type. Perhaps the greatest significance of possession on the farm of these two compounds is practical: a combination of label instructions,

atropine, Ipecac Syrup and such household items as water, soap and milk allows the vast majority of pesticide poisonings which occur, to be treated adequately on the farm (although some sort of medical advice should still be sought). Without atropine or Ipecac, the ability of the farmer or family to allay significantly the effects of a poisoning is greatly reduced, and in a severe case, could make the difference between life and death.

The average number of items of recognized utility for treatment of poisoning held by farmers interviewed (excluding first aid kits because of their uselessness in this context) was less than one (0.97). In fact, as already mentioned, 45 possessed no aids, and so the average among those taking some measures was less than two (1.76). Only one farmer had both atropine and Ipecac, although it is likely that all those who had atropine alone also had salt which does have emetic properties. Only one farmer, therefore, was properly prepared with appropriate aids to handle a poisoning, irrespective of his ability to actually handle it. (This particular farmer had recently attended a meeting on farm safety conducted by the Farm Safety Officer of the Department of Labour and Industry based at Burnie. The author understands that this position no longer exists.)

Actual cases of poisoning on the farm were reported by 32 farmers - very close to one-third of the sample. A total of more than 43<sup>30</sup> instances were described by these farmers, and the ratio of human poisonings to animal poisonings was approximately 1:2. Because poisoned animals were frequently found dead or nearly dead, equally frequently little or no action was taken. Most cases were a result of ingestion of 1080 poison (a rabbit bait), but strychnine (also a rabbit or fox bait), lead and arsenical compounds (animal dips and fruit sprays), warfarin (rat and mouse bait), metaldehyde (snail and slug bait), fenthion ethyl (sheep jetting fluid) and other organo-phosphorus compounds, and formalin (foot rot remedy for sheep) were also thought to have been the causes of death in domestic animals and livestock. Where action was taken, a trip or telephone call to a veterinarian were the most common approach. In only one case was action taken by the farmer himself: a salt solution was administered to a dog which had eaten strychnine.

The cases of human poisoning described by interviewees varied from mild rashes to death (of neighbours!). The action taken varied considerably. In some cases there was no action, which sometimes appeared justified, but at other times, seemed outright negligent. In other instances, action consisted of the drinking of a pint of milk after "blacking out", washing thoroughly and stopping spraying, and administration of atropine. Of the 15 cases of human poisoning mentioned, it was interesting to note that medical aid of any type was sought on only five occasions.

4.5.2 Methods of disposal for both pesticides and containers are analysed in this section. However, because it relates to both waste forms, an analysis of farmers' awareness of the existence of tips, and of their attitudes towards them is presented first.

<p>Q.30. Are you aware of any type of facility in your district - but not on your property - where pesticide containers or unwanted pesticides may be disposed of?</p> <p>No <input type="checkbox"/> - proceed to Q.32</p> <p>Yes <input type="checkbox"/> - proceed to Q.31.</p> <hr/> <p>Q.31. What are these facilities?</p> <p>Do you use them? No <input type="checkbox"/> - Why do/don't you use them?</p> <p>Yes <input type="checkbox"/></p>	<p>Q.30., 31.: Were aimed at determining the proportion of farmers disposing on the farm or on local tips. The final question* was rephrased, "Why do you prefer to dispose on the farm/tip?". Answers to Q.31. were varied, with much overlapping. The analysis below is therefore largely qualitative.</p>
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Of the 100 farmers interviewed, 79 were aware of the existence of public (not necessarily municipal) tips in their area. Of those, 46 (58%) made use of this facility for disposal of either or both of their pesticide and container wastes.

Those who disposed of these wastes on the farm did so for a variety of reasons, among which two were predominant. Firstly, disposal on the farm was easier, and this was frequently qualified by the comment, that the public tip was too far away. Secondly, the farmer felt that disposal on the farm was adequate, and so a trip to the tip was unnecessary. Disposal on the farm was frequently described as safer than at the tip. The only other frequent justification of farm disposal was its greater cheapness; it was

not determined whether this was a comment on the cost of travelling itself, of travelling time, or on higher municipal rates arising from greater (and perhaps troublesome) use of public facilities.

Not surprisingly, the farm-disposers made criticism of municipal tips as a site for disposal of toxic wastes. Most common was the aspect of access to the tips, particularly to children. An extension of this criticism was the question (more often than statement) asking whether local tips were adequately controlled in terms of access to, and burial of waste. A number of farmers expressed concern at the possibility of toxic residues building up at tip sites, and of seepage of wastes into watercourses, etc. Other criticisms were made, but do not bear recording here.

Among those who favoured disposal of these wastes in public tips (and who also used this approach), justification was largely on grounds of expedience. For example, it was claimed that there was either no space, or no existing facility (a hole) on the property; it was easier to use the tip; the tip was close-by; these wastes could be carted with other wastes to the tip; or, the costs in time and money to dig a hole on the property could be avoided. Aesthetic reasons (tidyness and appearance) rated high as reason for using a public tip, as did also cheapness (probably in comparison to digging a hole on the farm). Aspects of safety received less emphasis than many of these other justifications for tip use, and they included the possible build up of pesticide residues on the farm, and the possibility of water contamination. Proportionately, a higher number of farm disposers than of tip-disposers justified their practice on the grounds of greater safety.





degradation of pesticide containers to the point that movement would precipitate collapse; (vi) unpleasant side-effects resulting from the application of a product; (vii) small impractical quantities of (tankmix or concentrated) pesticide remaining after an application operation; (viii) change of crops on the farm, such that existing pesticide stocks have no future application potential on the farm; and (ix) experimental compound from a manufacturer was left on a property with no directions for future use.

Disposal technique of farmers was assessed as described above on Page 204. Of the 31 who had accumulated waste pesticide, less than half had made a positive effort to dispose of their wastes, and in some cases these wastes were (re)discovered as a direct result of the author's visit. It is self-evident, that where wastes existed but had not been disposed, they were still to be found stored in some way. The reasons given for *prolonged* storage were either, that for practical purposes, the existence of a pesticide had been forgotten, or more significantly, that disposal of the waste had been considered but planned action had foundered on ignorance of method.

Only 17% of those who had disposed of or generated pesticide wastes used a hole dug specifically for the purpose or had taken the wastes to a local tip. By far the most common practice was disposal onto ground (e.g., onto road, roadside, paddocks, gravel or stone yards, or in the vicinity of sheep yards or dairy sheds) and this method was used alike for tankmix and concentrated pesticide. There was never evidence to suggest that concentrate was diluted prior to disposal - an aspect of recommended disposal technique which was not part of the scored assessment. Much less frequently employed, but of approximately equal use were existing holes (such as rabbit warrens, old fencepost holes, hollow stumps, sink-holes in limestone country, and an old well), tips on the farm (such as holes used traditionally for carcase disposal or burning off), and 'disposal' by default (the rusting and collapse of partly

full containers, of which four instances were discovered). Other disposal methods which were employed included the pouring of waste herbicide onto weed patches, disposal into a creek flowing through the property, or disposal into plant or animal wastes (e.g., into sheep manure under a sheepshed or into compost). Among the actual methods employed were some particularly bad examples: disposal onto a pile of rubbish on the banks of a dam, the water in which was used for a variety of purposes; disposal into an old well replenished by groundwater conceivably feeding other wells or springs; disposal each week into compost used ultimately on crops; disposal in limestone sink holes where destination of the wastes is completely unknown; and disposal of a mercurial preparation directly into a creek.

It can be seen that no particular pattern of disposal practice emerged, and that the methods employed depended to a significant extent on disposal opportunities created by the particular natural or other features of a farm or locality. If any features were common to most disposal efforts, they were their incorrectness and their expediency.

Basic Method of Disposal	Number of Cases	Percent
Disposal onto ground	14	33
Improper disposal into hole	7	17
Proper disposal into hole, or to municipal tip	5	12
'Disposal' by disintegration of container	4	10
Disposal into general farm tip	4	10
Disposal onto weeds or "grubby patch" in pesticide	4	10
Other (see text)	4	10
Total	42	

Table 20 : Methods of pesticide disposal employed.

Although the disposal methods adopted by most left a significant gap between actual and recommended methods, the practices were not entirely without merit. The method of assessment is given earlier in this section (Page 204) and the average mark from a possible of 10, was approximately 2.5. The points of correct disposal which received greatest frequency of attention were inaccessibility to children and livestock, and separation of the disposal site from water. Middle-ranking priority of treatment was given the distance of site separation from home, and relatively low-grade attention was ascribed to such things as cover over the deposit, lack of access to wildlife, and the addition of lime to the pit.

Facet of Disposal	Number of Farmers Carrying Out This Practice (Maximum 31)
Prevention of access to children	13.3
Disposal further than 50 m from water	10.0
Prevention of access to livestock	9.5
Disposal more than 500 m from home	7.5
Covering of deposit	5.7
Prevention of access to wildlife	5.0
Addition of lime to waste disposal	0.0

Table 21 : Emphasis given different aspects of disposal method

One further aspect of disposal was not covered directly by questions put to the farmer, namely, the fate of spent dipping fluid from sheep dips and sprays. In the majority of cases, the fluid was pumped onto the ground in the immediate vicinity of the area of use - sometimes onto ground accessible to stock, sometimes not. Whilst it is unlikely that the farmer gave much thought to the possible consequences of such a practice, in practice it also is not entirely without merit, and is not far removed from one British recommendation<sup>31</sup>. Fluid

pumped from the dip or spray-sump onto soil is exposed to sunlight, oxygen, the diluting effect of rain, the action of soil microbes and the immobilizing effects of colloids. Moreover, at the time of last use, concentration of the active ingredient (already diluted for use), may well be below recommended strength. Finally, the dipping fluid is normally emptied out after remaining for a year in a situation where it has been subject to microbial action (in particular), sunlight, oxygen, the dilution effect of winter rain, and interaction with the clay and plentiful organic matter transported by sheep into the dip or shower. Nevertheless, the possibility of runoff into streams or dams nearby, or the build up of soil residues (probably temporary, but at peak levels when sheep are in and around yards) remains. Notable exceptions to this expedient method of disposal were discovered. In one case, dip was emptied into 200 litre drums and transported approximately 500 m for seemingly safe disposal in a naturally occurring isolated rocky gully. In a small number of additional cases, there had been incorporated an easy and seemingly safe disposal device into the dip or shower. No evidence of adoption of the sheep dip disposal pit designed by Gillham<sup>32</sup> was in evidence, but details of this were published only in 1980.

#### B. Container disposal

Q.24. If a farmer applies pesticides to his crops etc., he will from time to time have newly emptied pesticide containers on his property. He may, for example, accumulate these containers in a pile, use them for other purposes, do something else with them, or adopt a combination of some or all of these possibilities. Could you, please, describe as accurately as possible, what you do with your empty pesticide containers? Where there is more than one treatment, please mention each. (Subject not shown list).

double rinse with caustic soda/detergent ☐

secure storage before disposal. No accumulation ☐

recycle large drums ☐

no re-use for raft, feed trough, water storage ☐

site (Q.38) ☐

don't burn phenoxy-types ☐

burn paper, plastic, fibre, etc. but not hbc. ☐

non-burnables: break, puncture, crush, de-bung bury. ☐

Comment:

Probe: different treatment of different container types  
different treatment of different container contents  
is any application done by contract. If so, does contractor leave/take containers?

Q.24.: Only 99 assessments were possible because one farmer had just arrived on the property and had not disposed of any containers.

Q.38. Could I please see where you dispose of your pesticide containers and unwanted pesticides? Is this the only place? (Evaluate site)

Q.38.: In addition to the one ineligible interviewee above, there

were a further six whose disposal sites were too far away or too inaccessible to allow inspection. In such cases, a verbal assessment was made.

The method of assessment of container disposal has already been described earlier in this section (Page 205). Of the 99 assessable cases, 97 (98%) had made a positive attempt to dispose. For containers not burnt, the local tip or a disposal pit of some sort on the property were the final destination of containers for 64% of the interviewees. In the remaining 36% of cases, the most common end-point was a general, or sometimes specific pesticide container rubbish heap. These heaps were typically above ground level, and were usually without covering of any type so that leaching of residues from containers by rainfall was a distinct possibility. In general, there was only one point on a farm where containers were left, but in a small number of cases, containers seemed to have been left where they were emptied (e.g., around sheep or cattle yards). In some cases, an 'out-of-sight-out-of-mind' mentality seemed to prevail and heaps of containers in bushy, blackberry-infested areas had developed. Similar to the approach with pesticide wastes, natural holes such as sink holes or a quarry, were utilized. Other variations included disposal into an earthen dam wall, a rock ford, an old mine shaft, a well and an old dam. Waste containers of one fortunate farmer were removed annually by municipal authorities. Another claimed he re-used all containers for one purpose or another. Finally, one farmer who had a number of 200 litre drums adopted a 'dispose-by-storage' approach.

Container disposal, as it was practised, was typically a two-step process. The container was emptied, put at a temporary point of storage, and at some later date - anything between a few days and "years" - was moved to its point of final disposal.

In many respects, the place of temporary residence was the most important in terms of the potential risks associated with containers, and assessment of security at this stage was important in the total assessment of container disposal. If it is accepted that the practising of container rinsing, or of storage of empty containers behind a lock constitutes security at this stage, then 55% of properties left containers in a situation that some type of organism, humans included, was at risk. Clearly, the risk was not great in many cases, but it was an easily avoided risk. The time span of containers in the temporary residence situation for the 65 cases noted, was as follows:

Period	Frequency
0 - 1 week	6
1 week - 1 month	18
1 month - 3 months	18
4 months - 1 year	17
more than 1 year	6

Table 22 : Duration of temporary container residence before final disposal.

If practice were perfect, no point of temporary residence would exist. It is arguable, but also not unreasonable to suggest that anything more than a week is too long a period for temporary disposal. Accepting this as a basis of assessment, then 90% of farmers could improve this particular aspect of their disposal practice.

For the reasons just given, any priority which the interviewees seemed to give security at the point of final disposal appears partly misguided. Burning and covering of (finally) disposed containers received high priority treatment, as well as adequate distancing from the home. The same comment,

however, could not be made of attempts to separate final disposal sites from bodies of free water, and 27 (27%) of farmers interviewed disposed of their containers within 50 m of water, including 16 (16%) within 10 m of water. Bashing or holing of containers (to prevent re-use) received only moderate attention, and container re-use was avoided completely in only 45 cases (45%). In eight cases (8%), use of an unacceptable nature was revealed, and included use of empty containers as floats in dams, use for mixing and carrying feed for pigs, poultry, etc., or, with top and bottom removed, for placing around tomato seedlings. A considerable number of farmers used pesticide containers for carrying fuel and water for engines - acceptable, if not recommended practice.

Overall performance in disposing of containers was somewhat better than for pesticide disposal; the average score from a possible 12 was 8.3 (approximately 69%).

4.5.3 Method of Storage was assessed as outlined earlier in the section (Page 207).

<p>Q.35. Could I please, see where you store your pesticides? Is this your total stock, or is some stored or lying elsewhere? (Subject <u>not</u> shown list).</p>		<p>Q.35.: A total of 97 interviewees answered this question. In one case, assessment was incomplete, in another the store was too far away to allow assessment, and in a third, sighting of the store was not allowed.</p>	
specific cupboard, container	<input type="checkbox"/>	in original container	<input type="checkbox"/>
behind locked door	<input type="checkbox"/>	containers and labels intact	<input type="checkbox"/>
away from food, feed, water	<input type="checkbox"/>	herbicides, defoliant	<input type="checkbox"/>
		separate	<input type="checkbox"/>
<p>Comment: _____</p>			

Interviewees gave highest emphasis to cover from weather on the storage, and in fact, the score was perfect (100%). Storage of pesticides away from feed, food, water and fuel was a frequent feature of storage, and use only of original containers as well as distancing from the house received high priority attention. Middle-rating priority was accorded the holding of pesticide in sealed, intact and properly labelled condition, but all other aspects seemed largely unworthy of attention in the eyes of the

farmer, e.g., the use of a specific shed or cupboard for pesticides only, storage behind a lockable or merely closable door, prevention of access to wildlife, or separation of herbicides from other pesticides.

The average score obtained by interviewees was 4.8 out of a possible 10 (48%).

Aspect of Storage	Correct Practice Carried Out By:	
	(No.)	(%)
Storage under cover	97	100
Separation of stored pesticide from food, feed, fuel and water	77	79
Use of original containers only	75	77
Distance of storage from house greater than 20 m	71	73
Use of intact, adequately labelled, sealed containers	60	62
Closable door on cupboard or shed	34½	36
Separation of herbicide and other pesticide	21	22
Inaccessibility to wildlife	18	19
Use of specific shed or cupboard	8½	9
Lockable door on cupboard or shed	6½	7

Table 23 : Emphasis given different aspects of correct storage practice.



#### 4.5.4 Perceived need for help with disposal

Q.26. In order to do what you consider most appropriate with unwanted pesticides or pesticide containers, do you believe that help from outside the farm would be useful?

No ☐ - proceed to Q.28  
Yes ☐ - proceed to Q.27

Q.27. Who or what should or could help in this matter? How could help be given?

Q.26., 27.: These questions permitted the farmer to express, at least implicitly, reservations about his present method of disposal, or to make known areas of perceived undue compromise.

It was hoped that possible solutions to any perceived problems which were acceptable to farmers, would be elicited. There was also the chance that further insights into attitudes or problems of disposal may be forthcoming.

Overall, 44 subjects (44%) believed that some help would be useful in reducing disposal problems. The most common suggestion was instigation of a collection service for both containers and pesticides. It was thought that this service may be provided by the municipal council, by the supplier (retailer), or by a voluntary organization such as the Lions Club. The next most frequent suggestion was for more advice on how to go about disposal on the farm; actual on-farm advice was thought by some to be the best way of getting the ideas over. Availability within reasonable distance of a point of disposal was a common suggestion. However, this suggestion was often accompanied by comment on the need for completely adequate supervision of such a facility. The only other frequently forthcoming suggestion related to recycling of containers. Other suggestions or requests included publication of advice on the times when local municipal tips were being covered, the levying of a deposit on containers, or refilling directly into 'old' containers on the farm (with the same product as it had contained earlier).

In a few instances, the notion of help was criticised and the most common grounds were the likelihood of increased cost of pesticides or of municipal rates, depending on who rendered the assistance. The dissenters took issue also with the possibility that high concentrations of toxic substances could build up in a specific pesticide and container disposal area, and with the possibility that such wastes may be handled by people ignorant of their dangers.

Nature of Disposal Assistance	Frequency of Mention
Provision of waste collection service	17
Provision of advice on disposal technique	11
Provision of safe, effective point of disposal	9
Provision of container recycling service	7
Provision of some means to get wastes off farm	2
Provision of advice on when local tip being covered	2
Levying of deposit on container	1
Provision of bulk pesticide delivery service	1

Table 24 : Suggested methods of help with disposal of pesticides and containers.

#### 4.6 Magnitude and nature of disposal problem

Whilst the data elicited in response to Question 4 (see below, Page 228 ) would allow some calculation of the quantity of pesticide used in Tasmania, in the general context of this document, this point has little relevance. Rather, the quantification of container generation and waste pesticide generation was of interest and these are analysed below.

#### 4.6.1 Quantity of waste pesticide generated or disposed

**Q.21.** These unwanted pesticides, which you may have as liquids, powders, granules, gas or in other forms, can be handled in a variety of ways, and sometimes the farmer is uncertain of which is the best of the possible alternatives. Which of the following procedures did you follow with your unwanted pesticides? (Show subject list. Mark more than one, if appropriate.)

a. burnt it	<input type="checkbox"/>
b. threw it on my rubbish heap	<input type="checkbox"/>
c. took it to the local tip	<input type="checkbox"/>
d. threw it in a dam, creek, gully etc.	<input type="checkbox"/>
e. buried it	<input type="checkbox"/>
f. didn't know what to do, and still have it stored away	<input type="checkbox"/>
g. applied it to crop etc.	<input type="checkbox"/>
h. poured it down a drain	<input type="checkbox"/>
i. poured it into the toilet	<input type="checkbox"/>
j. put it into other containers	<input type="checkbox"/>
k. left/poured it by the roadside	<input type="checkbox"/>
l. poured it into a sump	<input type="checkbox"/>
m. gave it away	<input type="checkbox"/>
n. other. Specify _____	<input type="checkbox"/>

Could you please describe in detail how you went about this/these procedure(s).

Where buried: (subject not shown list)

Dilute to use strength	<input type="checkbox"/>	Line with lime	<input type="checkbox"/>
Hole of 18"+	<input type="checkbox"/>	Allow to soak in	<input type="checkbox"/>
		Cover with soil	<input type="checkbox"/>

When last did you do this? \_\_\_\_\_ And before that? \_\_\_\_\_

Approximately what quantity of pesticide was involved on these/this occasion(s)  
kg                      It

As recorded above, 31 interviewees had accumulated or disposed of quantities of waste pesticide. The figures given below, which can best be described only as approximations, refer largely to concentrates. Because the disposal, one way or another, of tank-mix pesticides would be an almost universal occurrence, the right-hand side of the table below is deemed a gross understatement.

Concentrates	
<u>Herbicides</u>  2,4-D - ?* Gesapon - ? Gesatop - 4 lb Ramrod - 9 kg Tok E - 4 x 20 L, 10 L, - ? Weedone - 1 gall  <u>Insecticides</u>  Organophosphorus compounds: Nucidol - 5 L Phosdrin - 1 pt Sumithion - 20 L  Organochlorine compounds: DDD - ?	<u>Insecticides (cont.)</u>  Organochlorine compounds (cont.) DDT - 200 L, 20 L, 2-3 L, - ? x 7 Dieldrin - ? Dielfly - ? Gammatox - 1 lb  <u>Rodenticides</u>  Larvacide 100s of bottles, - ? x 2 1080 - ?  <u>Miscellaneous</u>  NAA - ?  <u>Unknown</u>  More than ten cases
Tankmix, Etc.	
Sheep dip - numerous Atrazine - ? Unknown - more than ten cases	

\* '?' - means unknown quantity.

Table 25 : Description of waste pesticides generated by interviewees.

#### 4.6.2 Quantity of pesticide containers generated or disposed

Q.4. This question relates to your actual pesticide usage, and I asked in my letter whether you could perhaps answer the question before I called. Were you able to complete the table? (Probe any problems, difficulties and in all cases, look at table. Where no work done, repeat the questions).

a. Was any of your pesticide spraying or application in the last 12 months done by contractor?

No ☐  
 Yes ☐

- all ☐  
 - some ☐

b. Could you please tell me, in relation to your total pesticide use on this property for the last 12 months

- (i) what pesticides were used? (Trade name, or generic name and maker).
- (ii) what percent active ingredient (as on label) was in the product?
- (iii) size of each container emptied?
- (iv) number of each container?
- (v) what was the container made of? (Steel, tin, plastic, glass, paper, cardboard, cloth etc.)

Product & Manufacturer	% Active Substance	Container Size (kg/lt)	No. of Containers	Container made of:-

Q.4.: The initial wording reflected a late change in mind of the approach to the farmer, and in fact no letters were sent out in advance of the actual visit. The question about contractors was necessary to establish whether another source of containers requiring disposal existed.

The answers to this question had the obvious weakness that they relied heavily on memory of events up to a year prior to the interview.

Because containers made of plastic, paper, cloth and other combustible material can be easily (and correctly) disposed of by incineration, they represent no problem of significance. Their numbers were therefore, quantified only very approximately, and it was found that approximately twice as many burnable containers as non-burnable empty containers were generated. It should be noted, however, that a significant proportion of these were small plastic bags used as 'inners' for carrying powders, granules, etc.

If the numbers of non-combustible containers generated by the 100 farmers surveyed are extrapolated to cover Tasmania's total farming population, then the total number generated in 1980 would be as below:

Product Type	Container Type*			State Total*
	Glass	Tin	Metal	
<u>Insecticide/miticide</u>				
Organophosphorus, carbamate	4 000	10 301	15 068	29 371
Other	0	1 236	2 001	3 237
Total	4 002	11 537	17 069	32 608
<u>Herbicides</u>				
Phenoxyacetic	0	6 003	8 123	14 126
DNBP	0	824	0	824
Organophosphorus, carbamate	0	1 177	177	1 354
Other	0	1 354	706	2 060
Total	0	9 358	9 006	18 364
<u>Fungicides</u>				
Heavy metal	0	0	0	0
Other	0	1 942	118	2 060
Total	0	1 942	118	2 060
<u>Rodenticides</u>				
Larvacide <sup>®</sup>	59	59		118
Ratsak <sup>®</sup>		59		59
Total	59	118		177
<u>Other</u>				
Formol <sup>®</sup>	0	0	647	647
SAP <sup>®</sup>	0	59		59
Total	0	59	647	706
<u>TOTAL</u>	4 061	23 014	26 840	53 915

\* These figures have all been extrapolated and rounded. Discrepancies are due to the effect of rounding.

Table 26 : Annual generation of non-burnable pesticide containers in Tasmania.

Calculations to obtain these figures were based on two facts:

firstly, the total number of rural establishments in Tasmania in 1979/80 was 6,180<sup>33</sup>, and secondly, for every 105 farmers,

five do not use pesticides<sup>34</sup>, i.e., 95.2% of farmers used

pesticides. It must be pointed out that, when farmers were asked about pesticide usage, they were asked to confine estimates to

only one property where they owned more than one. Thus, pesticides were taken to be used on 5,886 properties, and average quantity used by hobby and other farmers was assumed to be the same as for *bona fide* farmers.

The approximately 54,000 containers generated annually should be disposed of by some form of landfill. Of these, approximately 57% have contained organophosphorus or carbamate compounds which, in relation to other chemical groups, are among the more toxic of pesticides. Other compounds which can be acutely toxic to vertebrates, such as DNBP, Larvacide® (chloropicrin, and no longer sold), Ratsak® (warfarin) and S.A.P.® (white phosphorus), were held in containers accounting for only 2% of the total.

4.6.3 Incidence of poisoning has already been discussed (Page 212) and a total of 32 interviewees had experienced poisoning on their farm. Of the more than 43 incidents reported, none could be certainly attributed to inadequate disposal or storage method.

## 5. STATISTICAL ASSESSMENT

The statistical treatment in the previous segment of data gathered is very basic. Whilst correlations between a variety of variables could be examined, only a small number with practical orientation have been carried out. Where necessary, suitable adjustment has been made for the largely unavoidable gaps in data outlined above in the survey analysis. Implications of these findings are discussed in Chapter 4.

### 5.1 Correlation of knowledge and behaviour

The existence of any significant correlation between knowledge of correct disposal methods and the practice of these methods would be of interest to agencies planning to change practices for the better. Correlations of knowledge with method of container disposal were significant at the 0.05 level, whereas the correlation of knowledge with storage behaviour was not significant. Correlation between knowledge in the two areas and behaviour in the two areas was not significant.

### 5.2 Difference of behaviour between farms with and without valued or loved beings

Fear is a possible motivation for safe practice in hazardous situations. This motivation could also be of potential use in education campaigns for improved practices.

Differences in behaviour, firstly, between farms with and without resident children of age less than six years, and secondly, farms with (all of) children, pets, working dogs and livestock, and farms with three or less of these, were assessed. No significant behavioural differences were found in either case.

### 5.3 Difference of behaviour between farmers with differing farm enterprises

As noted above, the only significant differences existed between beef and dairy farmers.



NOTES

1. OPPENHEIM, A. N., 1966; Questionnaire design and attitude measurement; Heinemann Educational Books, Ltd., London, U.K.
2.     a. JACKSON, W., Department of Agriculture, Tasmania, 1981; Personal communication.  
       b. SHORT, J., Department of Agriculture, Tasmania; Personal communication.
3. PATTERSON, I. G., D. O. KIRKHAM, K. C. GILMORE, 1978; The changing rural environment; Centre for Environmental Studies, University of Tasmania, Australia.
4. In fact, three of these 16 were visited before it was discovered that the subject was unsuitable. In one case, the prospective interviewee was closely involved with farm safety in a government department.
5. ANON., 1979; Occupation by age, in: Population and dwellings, Tasmania [from 1976 census]; Australian Bureau of Statistics, Canberra, Australia.
6. ANON., 1981; Agricultural establishments operated by agricultural and non-agricultural enterprises by industry of establishment, in: Agricultural sector, Australia, Structure of operating units; Australian Bureau of Statistics, Canberra, Australia.
7. This result was a little surprising, and should be viewed in the light that a number of the preceding questions dwelt heavily on poisoning and ill-effects of pesticides in the environment. However, this result is consistent with the results in Table 16, on p.197.
8. Label instructions always bear first-aid instructions including, where it is known, an antidote. Pesticides for which an antidote is known are in the minority, but for others, general first-aid measures have proven adequate. The label also bears comment on general safety precautions which should be taken. Many further sources of such information exist.

9. The Tasmanian Department of Agriculture published in August 1978 (Techfile 31/78, Agdex 688) a leaflet for farmers describing the meaning of these symbols. (Explanation has appeared also in at least two Department of Agriculture District Newsletters: Tamar, July 1989, and Devonport, July 1979). In addition, the full cautionary wording of all different label types is set out. The concepts of LD<sub>50</sub> and LC<sub>50</sub> are briefly described, and these two values for a number of pesticides are given.
10. Registration of a product rightly requires very specific instructions on target species, application rates and methods, timing of application, etc. Both farmer and manufacturer gain protection from fulfilment of this requirement. There is some ground for agreement that application instructions are not always clear, and this problem is currently receiving attention from registration authorities.
11. Label instructions always bear first-aid instructions including, where it is known, an antidote. Pesticides for which an antidote is known are in the minority, but for others, general first-aid measures have proven adequate.
12. DEPARTMENT OF THE ENVIRONMENT, 1975; Approved method of disposal of pesticide and pesticide containers, Tasmanian Journal of Agriculture 46, 81-85.
13. ANON., 1971; Disposal of containers and unwanted pesticides (wall chart); Agricultural and Veterinary Chemicals Association, Sydney, Australia.
14. In the course his work, the author has spent quite some time preparing data on poisoning by pesticides for Poisons Information Centres. These centres are manned by qualified pharmacists who in some cases are spending all of their time giving telephone advice on poisoning. In each State these Centres act as a repository for practical information on treatment of poisoning and are therefore considered better sources of information than doctors, hospitals, etc., who themselves often contact these Centres.

15. See, for example, ANON., undated; Poisoning; Nestle, Sydney, Australia.
16. OPPENHEIM, A. N., 1966; As Note 1.
17. The cost/benefit ratio from the use of pesticides is generally reckoned around 1:4, but this would vary according to the particular situation. See, for example, PIMENTEL, D., J. KRUMMEL, D. GALLAHAN, J. HOUGH, A. MERRILL, I. SCHREINER, P. VITTUM, F. KOZIOL, E. BLACK, D. YEN and S. FIANCE, 1978; Benefits and costs of pesticide rise in U.S. food production, Bio-Science 28, 772-784.
18. Withholding period is the time which must elapse between application of a pesticide to a crop or animal, and its harvest or slaughter for consumption.
19. DREISBACH, R. H., 1977; Handbook of poisoning: diagnosis and treatment; Lange Medical Publications, California, U.S.A.
20. As above.
21. PESTICIDES SECTION, Department of Primary Industry, 1980; A manual of safe practice in the handling and use of pesticides, pp.218-231, PB 377; Australian Government Publishing Service, Canberra, Australia.
22. ANON., 1971; as Note 13.
23. NOVAK, R. G. and O. H. HAMMER, 1979; Pesticide waste disposal, Part I, Down to Earth 26, 13-16.
24. PESTICIDES SECTION, 1980; as Note 21.
25. ANON., 1971; as Note 13.
26. PESTICIDES SECTION, 1980; as Note 21.
27. ANON., 1980; Farm storage of agrivet chemicals, AVCACode No. 2; Agricultural and Veterinary Chemicals Association, Sydney, Australia. (wall chart).

28. Atropine is a preparation readily available without prescription from pharmacies. It is normally available as tablets of 0.5g, and is used as a specific antidote for organophosphorus compounds and some carbamates.
29. Ipecac Syrup is also available from pharmacies without prescription, and is used to induce vomiting.
30. Because of repeated instances of poisoning on some properties, it was sometimes difficult to obtain accurate estimates.
31. MINISTRY OF AGRICULTURE, FISHERIES AND FOOD, and BRITISH CROP PROTECTION COUNCIL, 1980; Guidelines for the disposal of unwanted pesticides and containers on farms and holdings, p.7, Booklet 2198; Ministry of Agriculture, Fisheries and Food (Publications), Pinner, Middlesex, U.K.
32. GILLHAM, R. J., 1980; Safe disposal of used sheep dip, Farm Notes 34/80; Department of Agriculture, Tasmania, Australia.
33. Australian Bureau of Statistics, Hobart, 1981; Personal communication.
34. Farmers were screened for their pesticide usage at the time of the initial telephone contact. Five out of 105 asked, indicated that they used no pesticides.